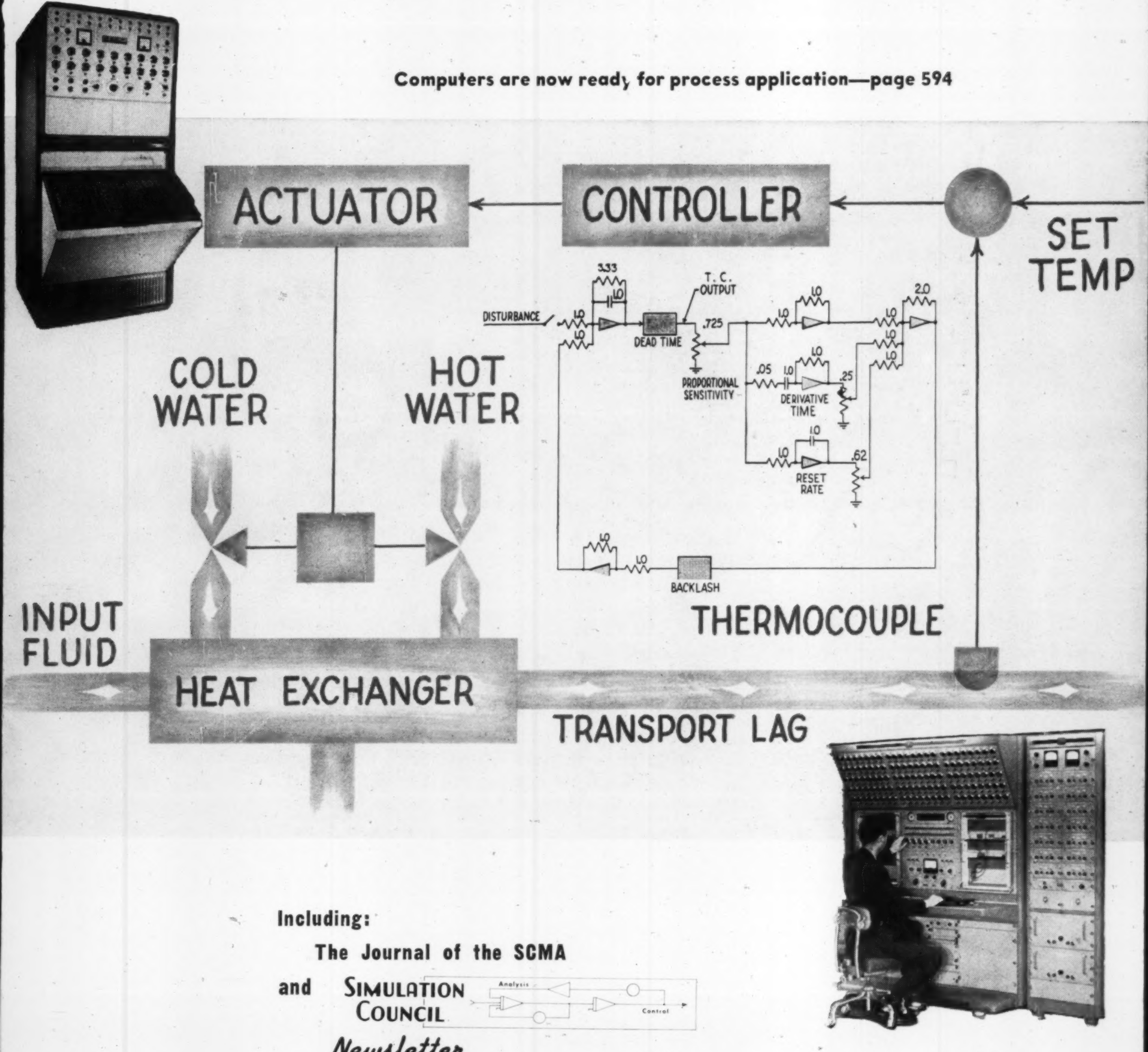
INSTRUMENTS and AUTOMATION

Computers are now ready for process application—page 594


ACTUATOR
CONTROLLER
SET TEMP
3.33
1.0
T. C. OUTPUT
DISTURBANCE
1.5
1.5
DEAD TIME
.725
PROPORTIONAL SENSITIVITY
1.0
1.0
2.0
1.0
1.0
1.0
.05
1.0
1.0
.25
DERIVATIVE TIME
1.0
1.0
.62
RESET RATE
COLD WATER
HOT WATER
1.0
1.0
BACKLASH
THERMOCOUPLE
INPUT FLUID
HEAT EXCHANGER
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Including:
The Journal of the SCMA
and SIMULATION COUNCIL *Newsletter*

Vol. 28, No. 4

APRIL 1955

BS&B

CONTROLS
SIZING
MANUAL

better performance
through accurate
valve sizing...

BLACK, SIVALLS & BRYSON, INC.

NOW!

An Entirely New Method For Sizing Controls!

BS&B's New, Exclusive Method Takes Both The GUESS And The WORK Out Of Controls Sizing For Liquid, Steam And Gas Applications!

Today's modern and complex processing systems require accurate control valve sizing. No one has recognized this fact more than BS&B.

Therefore, as a service to industry, BS&B set out to develop a new, simple, more accurate method of sizing controls. Here it is in the new BS&B Controls Sizing Manual.

This new, exclusive method uses two new "tools" to make sizing more accurate—the SIZE-O-GRAPH to determine what the valve MUST do and Cv RATINGS to determine what the valve WILL do.

These "tools" are based upon thousands of hydraulic flow tests performed on all sizes and types of BS&B Controls in the industry's largest and most modern flow testing laboratory. Results are proven by correlation with *actual* gas and steam flow tests.

If you'd like a copy of this new manual, write to . . .

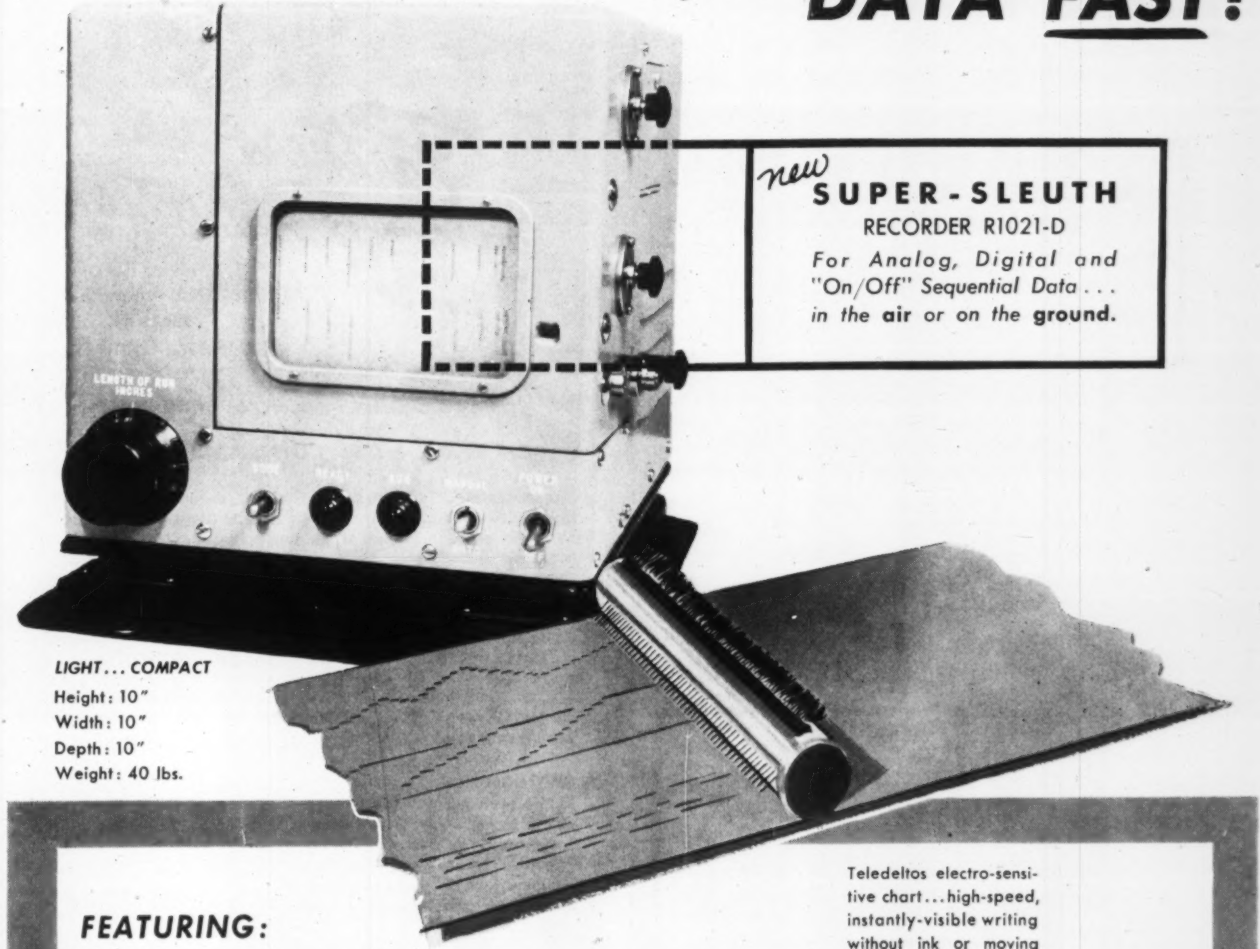
EFFICIENCY
OVER 60 YEARS
BS&B
RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-V4
7500 East 12th Street, Kansas City 26, Missouri

For more information circle 1 on inquiry card.

A SHORTCUT FOR GETTING *Accurate* DATA FAST!



new
SUPER-SLEUTH
RECORDER R1021-D
*For Analog, Digital and "On/Off" Sequential Data . . . in the **air** or on the **ground**.*

LIGHT . . . COMPACT
Height: 10″
Width: 10″
Depth: 10″
Weight: 40 lbs.

Teledeltos electro-sensitive chart . . . high-speed, instantly-visible writing without ink or moving writing elements.

FEATURING:

- **Ease of visual readability.**
- **210 writing styli unaffected by vibration and shock.**
- **Simplified semi-automatic and automatic data reduction techniques.**
- **High capacity simultaneous sequential data recordings.**
- **Low cost per channel of recorded data.**

The **Super-Sleuth** Recorder R1021-D has many commercial and industrial applications in automatically testing, monitoring, measuring and recording data for management evaluation.

Radiation, Inc. fixed multi-styli recording systems, featuring large data handling capabilities, help to economically simplify the solutions to instrumentation problems in Aircraft, Missile, Chemical, Mining, Petroleum and other industries. We invite you to submit your inquiries and application problems.

WRITE FOR FULL DETAILS — **RADIATION, Inc.**
Sales Department • P.O. Box Q • Melbourne, Florida

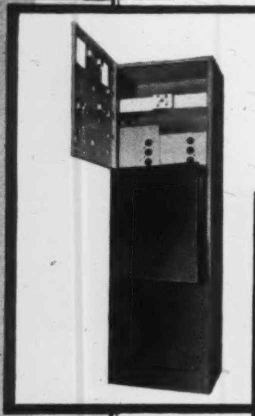
For more information circle **2** on inquiry card.

a good rule to follow:

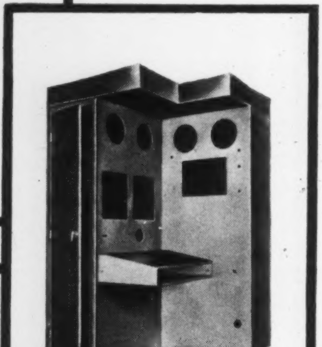
for cabinets, instrument panels, weldments, enclosures, cubicles, housings, chassis, consoles—

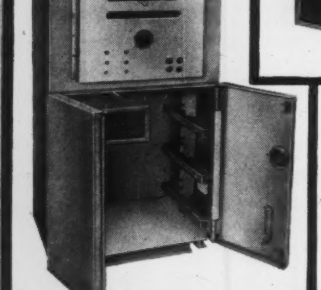
see Falstrom!

The measure of any company is its reputation—and for 85 years now, Falstrom has been the outstanding name in the sheet metal fabricating field. Under one roof, Falstrom maintains complete design and production facilities including the latest metal working equipment—all backed by men whose experience embraces every type of enclosure requirement. For all work in aluminum, steel and other alloys write for bulletin 142.



FALSTROM MEANS— IT'S THAT MUCH BETTER!





SINCE 1870

FALSTROM COMPANY
92 Falstrom Court, Passaic, N. J.
PRescott 7-0013

For more information circle **3** on inquiry card.

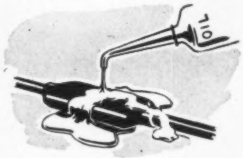
Partners in Production

Joy Electrical Connectors and Automatic Controls

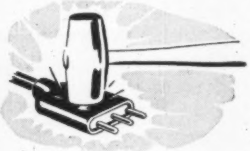
What happens to Automation . . . when electrical connectors fail?

No automatic control system yet devised will keep machines running when an electrical plug or receptacle in their power feeder line or power control circuit *poops out*. That's why JOY's one-piece molded Neoprene connectors deserve your careful consideration. Factory wired and permanently molded to cord or cable, they provide many extra advantages that add up to a long life of dependable service under the most adverse operating conditions. (A few are listed below.) Available in a wide variety of designs with 1 through 16 contacts for 150 to 600 volt applications. **Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.** In Canada: *Joy Manufacturing Co. (Canada) Limited, Galt, Ontario.*

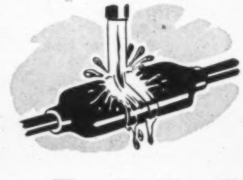
Oil-Sealed . . .
One-piece molded cable connector assembly protects conductors from oil and other external impurities. Face rings protect contacts from similar contamination, when connectors are engaged.



Distortion-Proof . . .
Factory molded as trim one-piece synthetic rubber jacketed units, JOY connectors cannot crack, will not shatter and are practically impossible to knock out of shape.



Moisture-Tight
JOY electrical connectors are absolutely moisture-tight from wiring juncture to face . . . and when connected even their contacts are protectively encased in a resilient housing.



JOY
INDUSTRY

Free . . .
New Bulletin —
Ask for No. B59

CD 355.2

JOY
SOURCE OF INDUSTRY'S
FAVORITE ELECTRICAL
CONNECTORS SINCE '28

For more information circle **4** on inquiry card.

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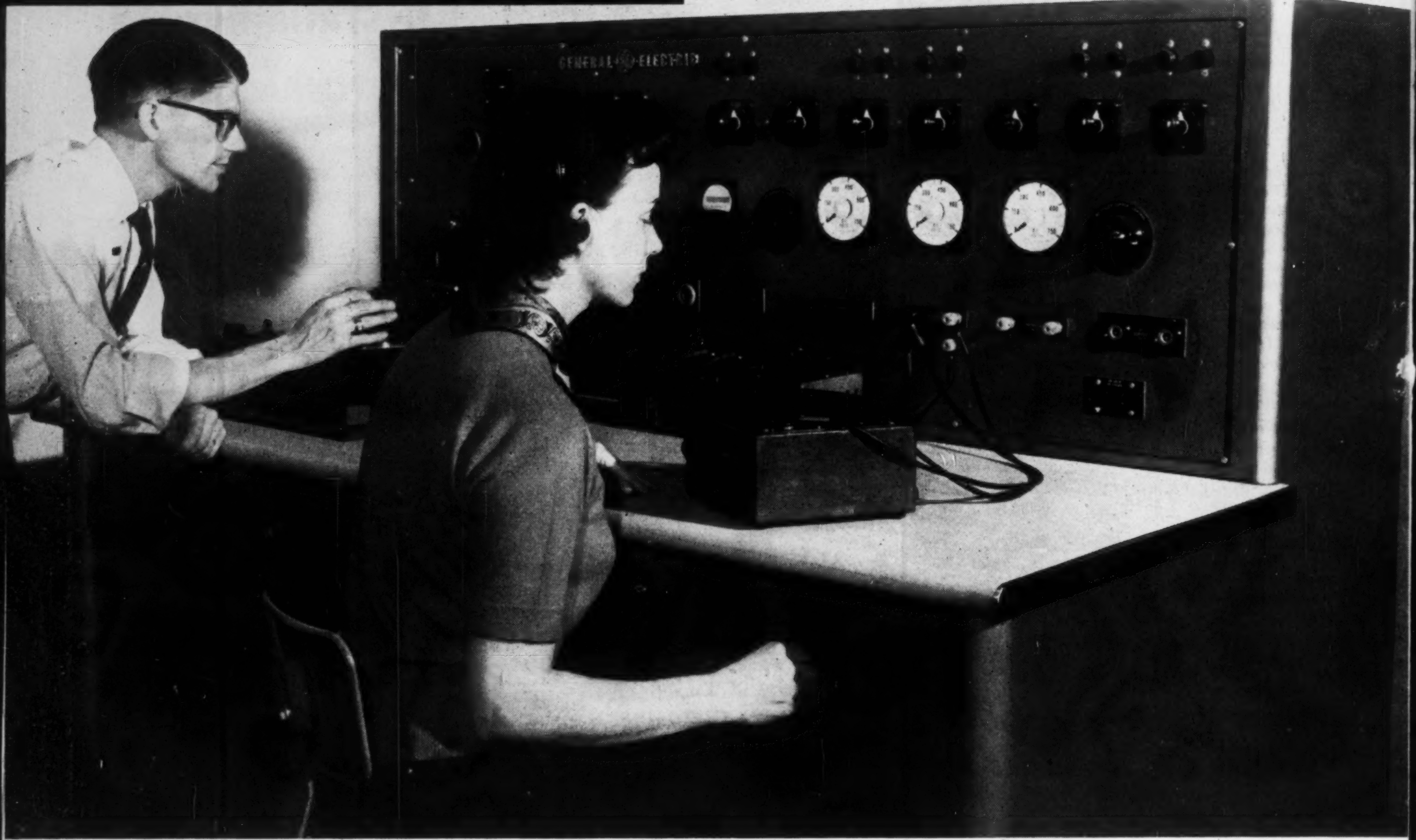
Developments in Laboratory Instruments



TO SAVE VALUABLE MAN-HOURS, G-E CONSOLE IS FUNCTIONALLY DESIGNED FOR SIMPLE OPERATION; FEATURES EASY-TO-REACH CONTROLS.

News About Other General Electric Instruments for Precision Measurement in the Laboratory

INSTANTANEOUS VAPOR DETECTOR

GENERAL ELECTRIC

FOR HEALTH MONITORING of mercury vapor and certain other toxic vapors, this portable General Electric instrument pinpoints contaminated areas; can be used wherever 115-v., 60-cycle power is available. $495.00.*

PHOTOELECTRIC RECORDER

RECORDING RAPIDLY CHANGING PHENOMENA with minimum load on measured circuit, recorder is available with sensitivity as low as 1 ua full scale. Response times as low as ⅕ second. $700.00.*

**Manufacturer's suggested retail price.*

For more information circle **5** on inquiry card.

Minimize Calibration Time With Versatile, Easy-to-use General Electric Instrument Standardization Console

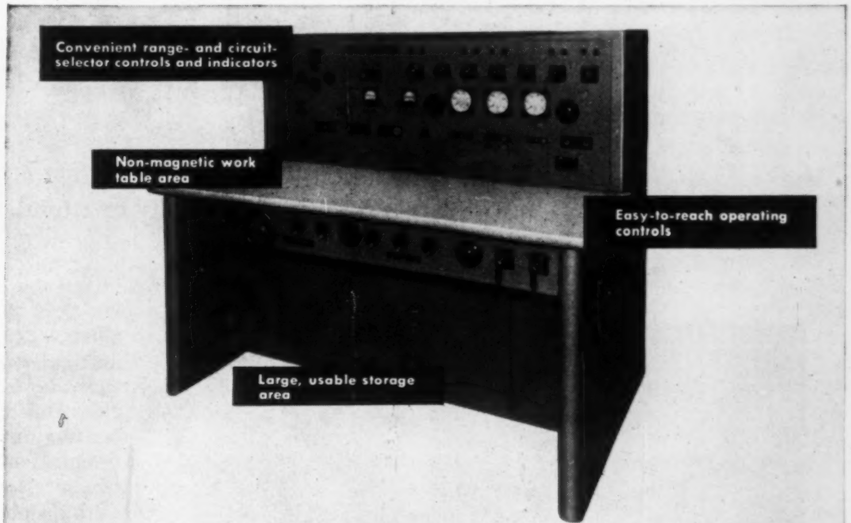
PROVIDES REGULATED POWER SUPPLIES FOR PRECISE INSTRUMENT CALIBRATION

The General Electric instrument standardization console provides regulated power supplies for precise calibration of a wide range of electric instruments.

HIGHLY ACCURATE, the console provides facilities for referring both d-c and a-c measurements to a standard cell, or to a laboratory standard instrument.

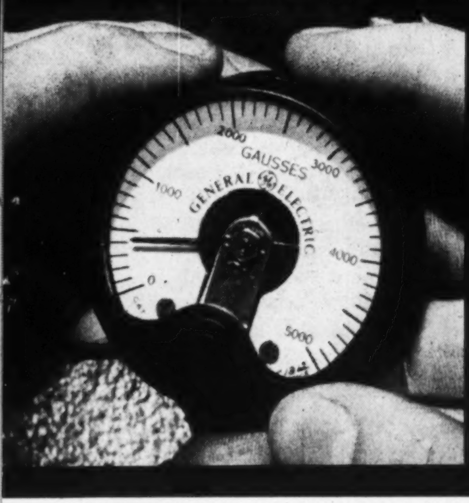
WIDE RANGES of a-c and d-c power supplied by the console facilitate the calibration of voltmeters, ammeters, frequency meters, and many others. Both a-c and d-c standardization tests can be made up to 750 volts, or 150 amperes; with low-distorted a-c frequencies from 50 to 3000 cycles.

FOR FURTHER INFORMATION about the General Electric instrument standardization console, contact your nearest G-E representative, or clip coupon below for Bulletin GEA-6005.


Convenient range- and circuit-selector controls and indicators
Non-magnetic work table area
Easy-to-reach operating controls
Large, usable storage area

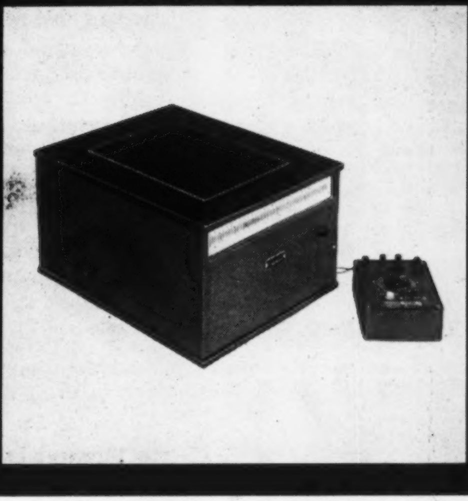
HIGHLY VERSATILE, the General Electric console has necessary switches, busses and indicators for calibration of a-c and d-c laboratory-standard, portable, small-panel, switchboard, and recording instruments. Requires only normal 115-v, 60-cycle source.

GAUSSMETER



CONVENIENT, POCKET-SIZE G-E meter facilitates checks of flux density and direction in magnetic gaps. Ideal for use in small or congested areas. Price including reference magnet and case, $67.10.*

INDICATING FLUXMETER



HIGH ACCURACY AND SENSITIVITY combine to provide precise magnetic measurement. Accuracy is ±1% of full-scale deflection; sensitivity is as high as 1 millimeter deflection per 100 flux lines. Price is $278.50.*

SECTION E605-76
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, N. Y.

Please send me the following bulletins:

- ☐ Instrument Standardization Console (GEA-6005)
- ☐ Instantaneous Vapor Detector (GEC-1275)
- ☐ Photoelectric Recorder (GEC-245)
- ☐ Equipment for Measuring Magnetic Properties (GEC-777)

NAME..............................

COMPANY..............................

STREET..............................

CITY.................. ZONE .... STATE.......

GENERAL ELECTRIC

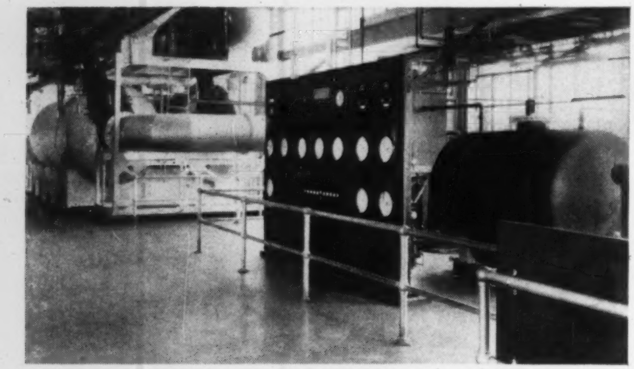
For more information circle **5** on inquiry card.

WHAT'S NEWS AT BRISTOL . . . WHAT'S NEWS AT BRISTOL

Bristol... automation... and you

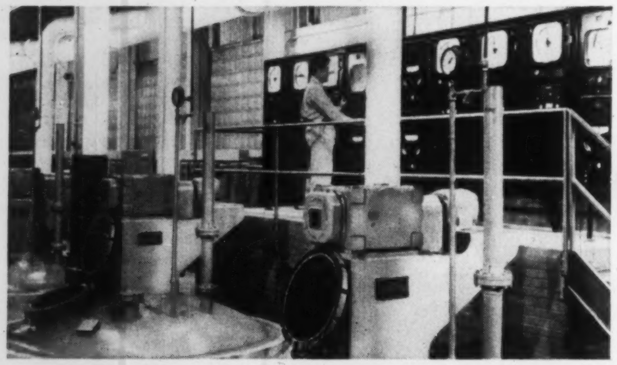
Magic word, automation. Or push-button operation. It's a breath-taking concept, too — plants running practically unattended.

Breath-taking — but not *new*.

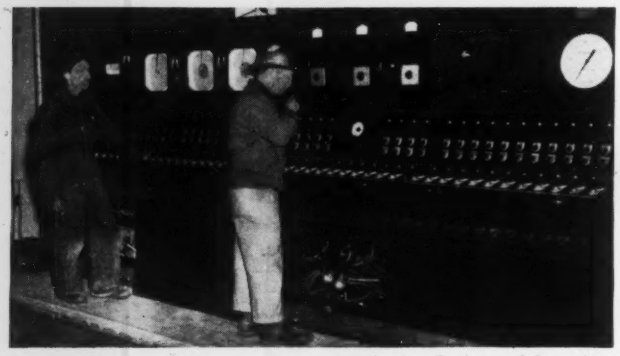


BRISTOL COORDINATED CONTROL SYSTEM automatically controls operation of "Columbia" Activated Carbon Solvent Recovery Plant at the New York Daily News. Similar control systems are used in many other solvent recovery plants designed and supplied by Carbide and Carbon Chemicals Company, a Division of Union Carbide and Carbon Corporation.

BRISTOL'S "MECHANICAL BRAIN" is the leader of the Coordinated Process Control System . . . accurately coordinating all the variables, including mechanical operations, so that each phase of the process takes place in proper sequence.



AUTOMATION is often thought of in terms of plans or even dreams; here at the Buffalo Foam Rubber Products Plant of the Dunlop Tire and Rubber Corporation, it is a reality. This automatic plant, designed and built by Mechanical Handling Systems, Inc., Detroit, uses Bristol Dynamaster® Electronic Instruments and Automatic Controllers as part of a process employing today's most advanced automatic production techniques. The result — greater efficiency and productivity, lower costs, improved product, and stronger competitive position.



THE WORLD'S LARGEST COAL CLEANING PLANT employs automation in lubricating system. The Hanna Coal Co., Adena, Ohio, uses *Bristol Controls and Recorders* in its fully automatic time-controlled centralized system for mass lubrication. This system promotes safety and, above all, insures positive delivery of the right lubricant in the right quantities at the right time to all bearings, regardless of operating conditions.

For more information circle 6 on inquiry card.

Twenty-one years ago . . .

'Way back in 1934, The Bristol Company led the way in the field of automation by developing the Bristol Systems of Coordinated Process Control.

These systems automatically controlled and coordinated all of the variables and operations of a process—such as the time of operation of valves, pumps, blowers, dampers, and the control, at a definite value or according to a time program, of variables that affected the uniformity, quality, cost, and yield of a product – such as temperature, pressure, liquid level, flow, pH, humidity, and speed.

RESULTS: They eliminated variations in processing that caused inefficiency – cut down rejections and waste – insured product uniformity – helped cut processing time as much as from 10 days to less than 30 minutes. And these systems quickly paid for themselves.

A REVOLUTIONARY CONCEPT: They brought automatic plant operation to a startling reality and were hailed at the time as a fundamentally new development – which would in time revolutionize manufacturing.

Today, Bristol Coordinated Control Systems are used in the chemical, oil refining, rubber, tobacco, textile, steel, metal working, food, paper, the automotive industries, and many others. They are so completely automatic that it is only necessary to push a button to start up, another to shut down.

The modern solution to processing and manufacturing control problems

Bristol's System of Coordinated Process Control is made possible only by the following unique combination of facilities, which have been developed during 66 years of building and applying thousands of automatic control systems and instruments in practically all industries:

1. The complete line of modern Bristol Automatic, Controlling, Recording, Electronic, and Telemetering Instruments, representing some of the most advanced ideas in instrument engineering.
2. Bristol's Fully-Automatic Time-Cycle Controllers or "Mechanical Brains".
3. Bristol's ability to combine electronics and the mechanical phases of automation.
4. The ability and facilities of Bristol's engineering staff, gained by long experience and Bristol's pioneering work in the field of automation.

Bristol Application Engineering is at your service:

Our application and field engineers are ready to solve control problems involving automation and Coordinated Process Control Systems by working jointly with your research, development, and plant engineers.

Have you an automation problem?

Our application engineers and nation-wide group of field engineers would like an opportunity to work with your technical staff on any problems of automation for which Bristol Controlling and Recording Equipment and Bristol Coordinated Control Systems appear to be the solution.

5.3

BRISTOL PRODUCTS:

Automatic Controlling, Recording, and Telemetering Instruments for:

Pressure, Vacuum, Absolute Pressure, Draft, Differential Pressure, and Barometric Pressure.

Temperature (Thermometers, Potentiometers and Pyrometers).

Flow, Water and Liquid Level, and Specific Gravity.

pH and Conductivity.

Speed of Travel and Rotation.

Humidity.

Voltage, Current, Power, and Load Totalization.

Mechanical Motion, Position and Operations

Including:

Automatic Control Systems
Electronic Potentiometers
Graphic Panel Instruments
Time-Cycle Controllers
Time-Program Controllers
Pneumatic and Electric Controllers
Instrument Panels
Control Valves

Write to The Bristol Company, 113 Bristol Road, Waterbury 20, Conn.

BRISTOL

TRADE MARK
BRISTOL'S
REG. U.S. PAT. OFFICE

POINTS THE WAY IN
HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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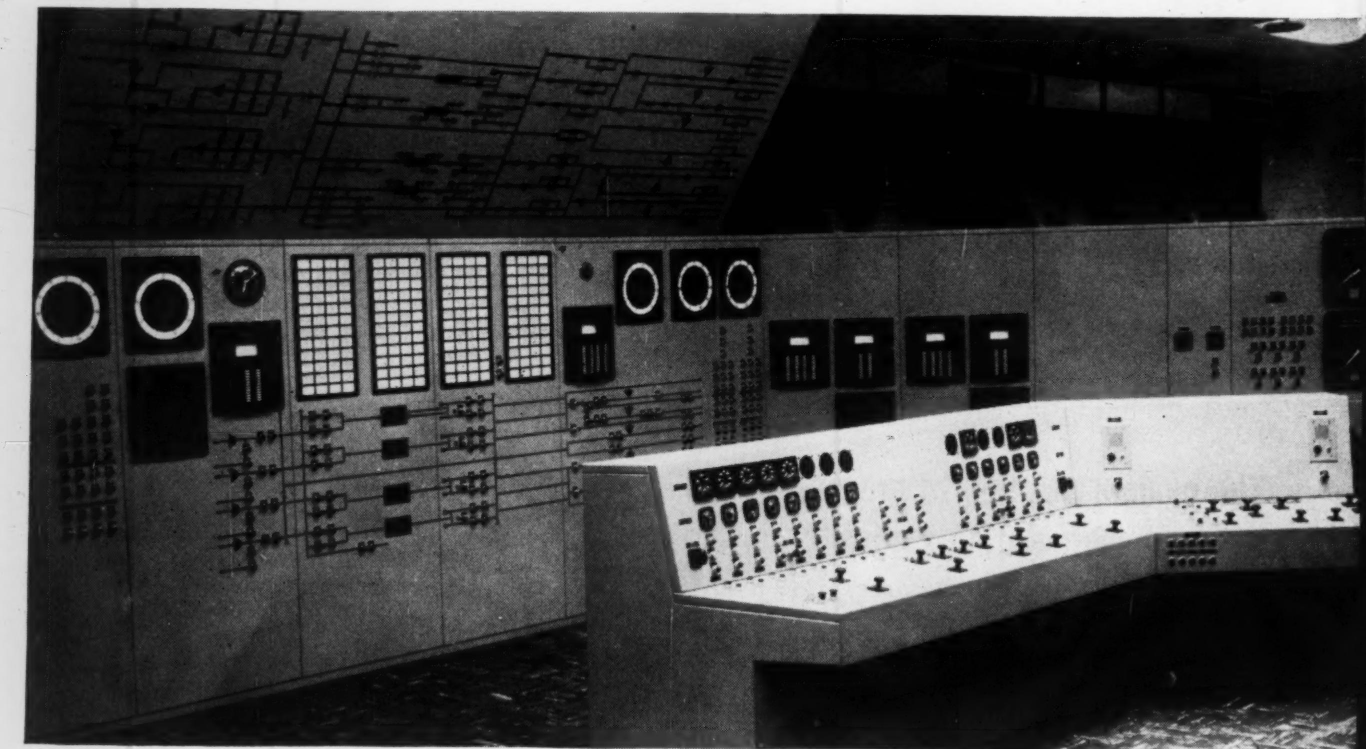
HAGAN Instruments

for Research · Development



Hagan supervisory control center for engine test facility

Hagan thrust stand
with ThrusTorq
measuring airplane thrust

For more information circle 7 on inquiry card.

and Controls

Production

Hagan can help you solve the Automatic or Manual Control and Instrumentation problems involved in the modernization of existing or the building of new Aeronautical or Automotive Test Facilities.

All of the following—and many others—are in successful use in Aeronautical Test Facilities in leading testing laboratories throughout the country.

Hagan Automatic Control has been furnished for:

ENGINE TEST FACILITIES—For use in controlling pressure, temperature, pressure ratio, volume or mass flow

WIND TUNNELS—Recirculating type; Blowdown type; Open loop type

PROGRAMMED SIMULATION OF FLIGHT

COMPRESSORS AND EXHAUSTERS

GAS TURBINES

BURNER STANDS . . . and many other applications

SURGE CONTROL—Hagan Pressure Ratio Indicators have been furnished for measuring and controlling pressure ratios for surge control of centrifugal compressors and exhausters. (Bulletin MSP-103A)

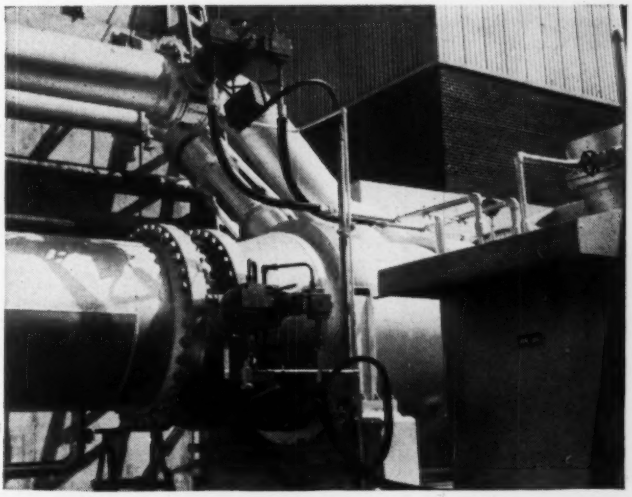
MASS FLOW MEASUREMENT—Hagan Mass Flow Meters have been furnished for measuring air flow corrected for absolute pressure and temperature variations, to indicate, record, integrate or control weight flow—or standard cubic feet per minute—or velocity. (Bulletin MSA-112)

THRUST AND TORQUE MEASUREMENT—Hagan ThrusTorqs have been furnished for measuring jet engine and rocket thrust—and cradle dynamometer load. (Bulletin 9345)

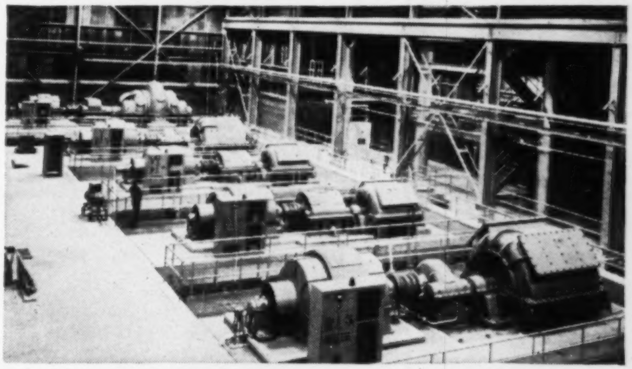
All of these systems have been designed with basic Hagan components. A system may use one or a combination of electric, hydraulic or pneumatic operating media to meet the specific requirements of the application. These systems, although designed for special applications, can be and are used in production lines. Hagan units and automatic controls bring new accuracy and flexibility to process control systems.

Hagan Corporation has its own Analog Computer for analyzing complex control circuits. Contract time is solicited for such problems as you may have.

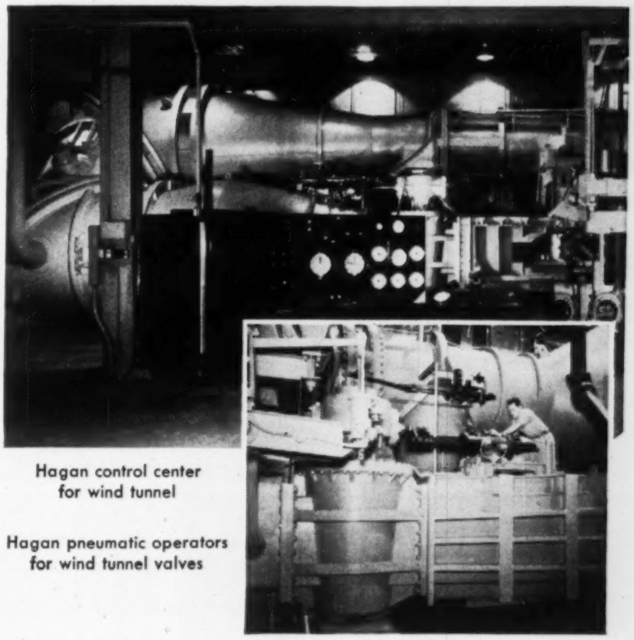
If you have a problem, write or call us or our nearest district representatives, located in principal cities.



Hagan electro-hydraulic valve operators for engine test facilities



Centrifugal exhausters with Hagan surge control for engine test facility



Hagan control center for wind tunnel

Hagan pneumatic operators for wind tunnel valves

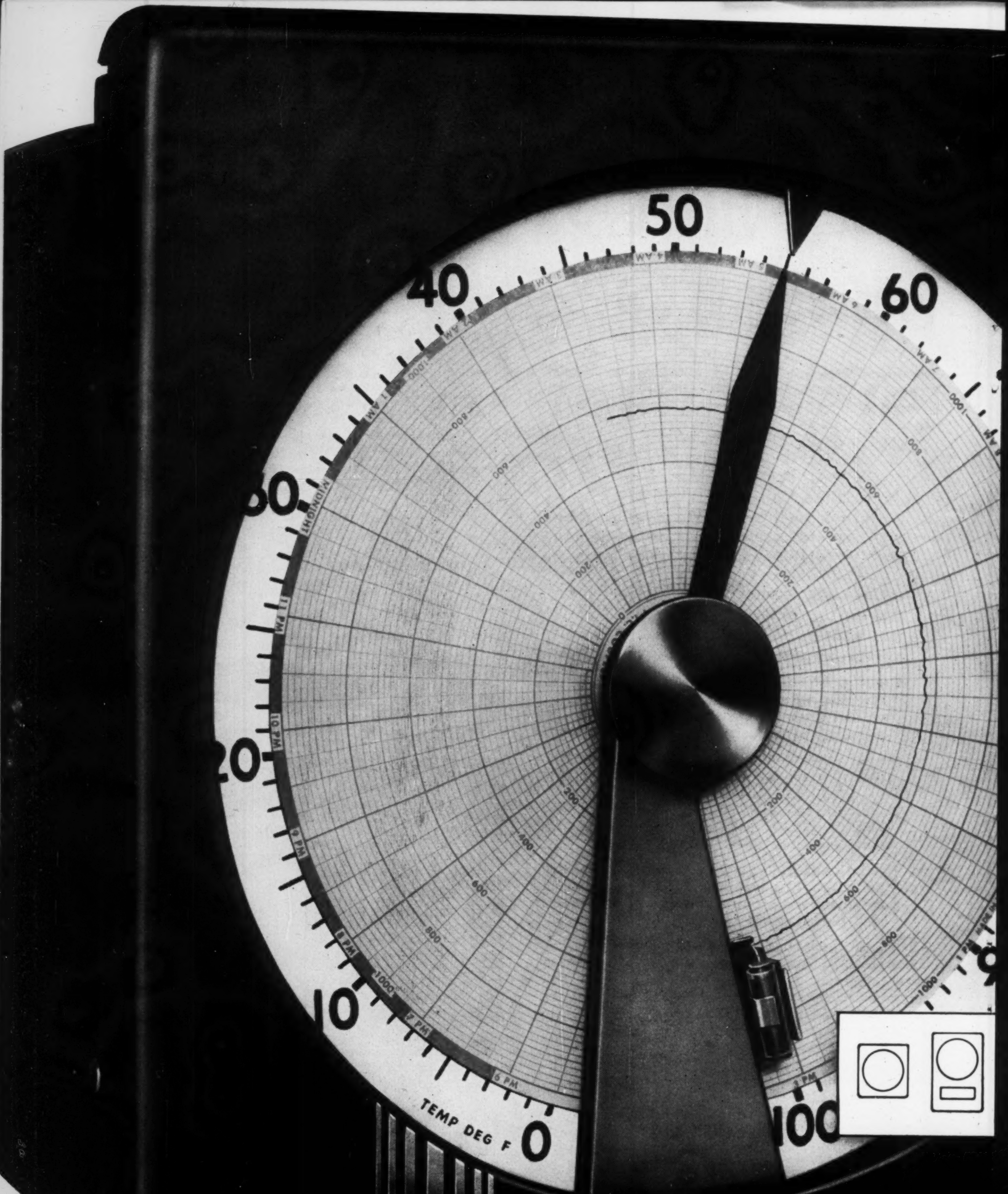
HAGAN
HALL
BUROMIN
CALGON

HAGAN CORPORATION

Hagan Building • Pittsburgh 30, Pennsylvania

Control Systems for Aeronautical and Automotive Testing Facilities • Ring Balance Flow and Pressure Instruments • Metallurgical Furnace Control Systems • Boiler Combustion Control Systems

For more information circle **7** on inquiry card.


50
40
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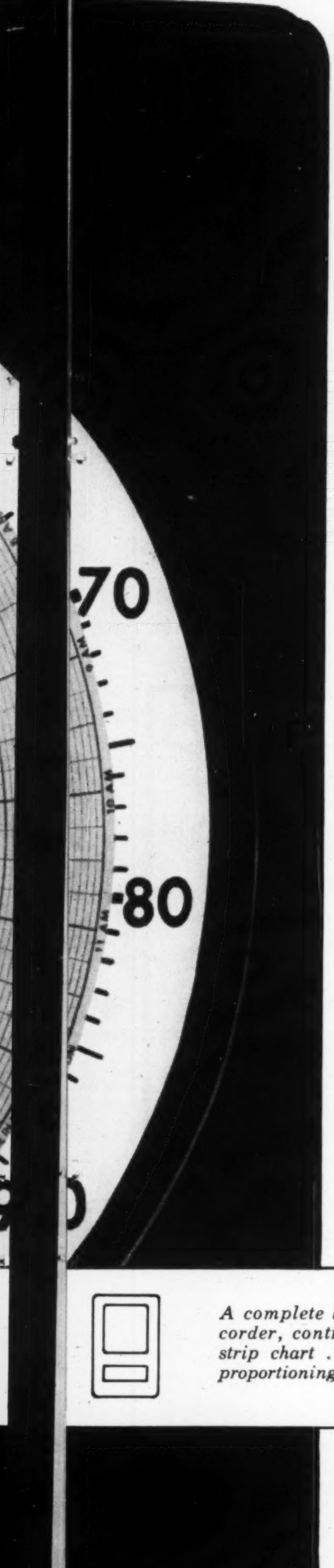
TEMP DEG F
LEEDS
NORTHRUP

For more information circle 8 on inquiry card.

Actual Size 11" x 12"



SPEEDOMAX® H

a new concept in instrumentation

Here's the new Speedomax H two-position recording controller. It is one of a complete line of electronic, null-balance potentiometer instruments that combines compactness with "big instrument" performance . . . outstanding simplicity of design with mechanical ruggedness. Speedomax H has design and construction features that result in multiple advantages unique in the field of industrial instrumentation.

Space-saver size—because of its efficient design. Its compactness permits substantial savings in panel space . . . two instruments can be mounted side by side in 24 inches.

Operating ease—is not sacrificed for size. Readability and "setability" of the Speedomax H illustrated are entirely comparable with that of conventional large size instruments.

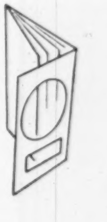
Instrument adaptability—to any temperature control problem. Available as an indicator, or round or strip chart recorder, with any selected control an integral part of the instrument.

On-the-job economy—in initial cost, in ease of installation and during year-in year-out service. The outstanding design simplicity and mechanical ruggedness of all parts meet L&N quality standards for continuous, trouble-free performance.

Streamlined production—from the simplest indicator to the most complete standard controller. The instruments you want are delivered when you want them because they are assembled from ingeniously designed, in-stock components, producing savings in point-of-application cost to you.

A complete line: Indicator, recorder, controller . . . round or strip chart . . . two-position or proportioning control.

To see for yourself, the features of Speedomax H, get our pictorial fold-out which takes you inside the instrument. Just phone our nearest office or write us at 4955 Stenton Ave., Phila. 44, Pa. and ask for Die-Out ND46(1).



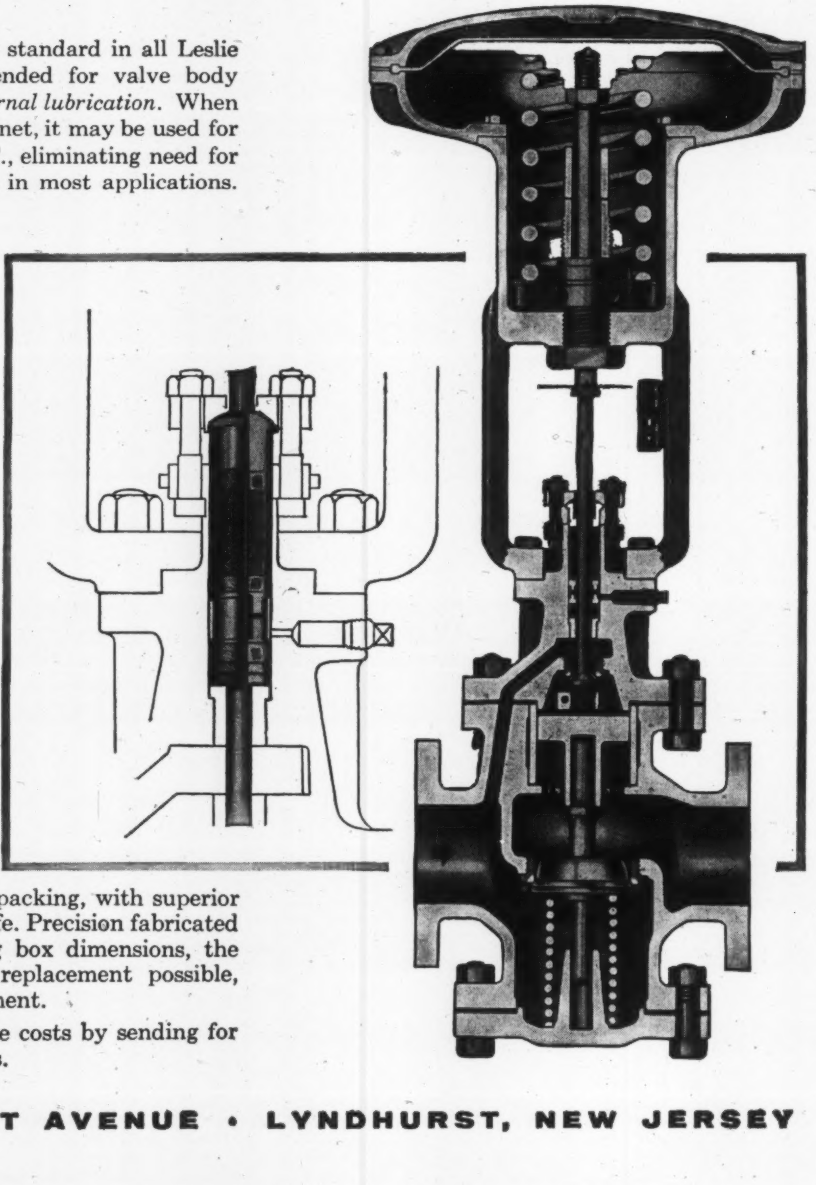
LEEDS NORTHRUP
instruments *automatic controls • furnaces*

For more information circle **8** on inquiry card.

How external lubrication is eliminated in

Leslie diaphragm control valves' new packing design

The new Leslie Lubrisoft® Packing now standard in all Leslie Diaphragm Control Valves is recommended for valve body temperatures up to 500° F. *without external lubrication.* When used with the Leslie thermo-isolating bonnet, it may be used for valve body temperatures up to 1050° F., eliminating need for external lubricators and isolating valves in most applications.



LESLIE LUBRISOFT® PACKING MEETS ALL 8 MOVING STEM SEAL REQUIREMENTS

Each of the several types of Lubrisoft split ring packing is specifically designed to maintain the low-friction stem seal against one or more of these deteriorative service conditions:

1. **Internal pressure, temperature and fluid**
2. **Contamination**
3. **Corrosion**
4. **Electrolytic Action**
5. **Oxidation**
6. **Extrusion**
7. **Abrasion**
8. **Friction**

Overall result is a standard, economical packing, with superior stem sealing properties and long service life. Precision fabricated to conform exactly to the deep stuffing box dimensions, the positive, split ring design makes fast replacement possible, without disturbing body or stem adjustment.

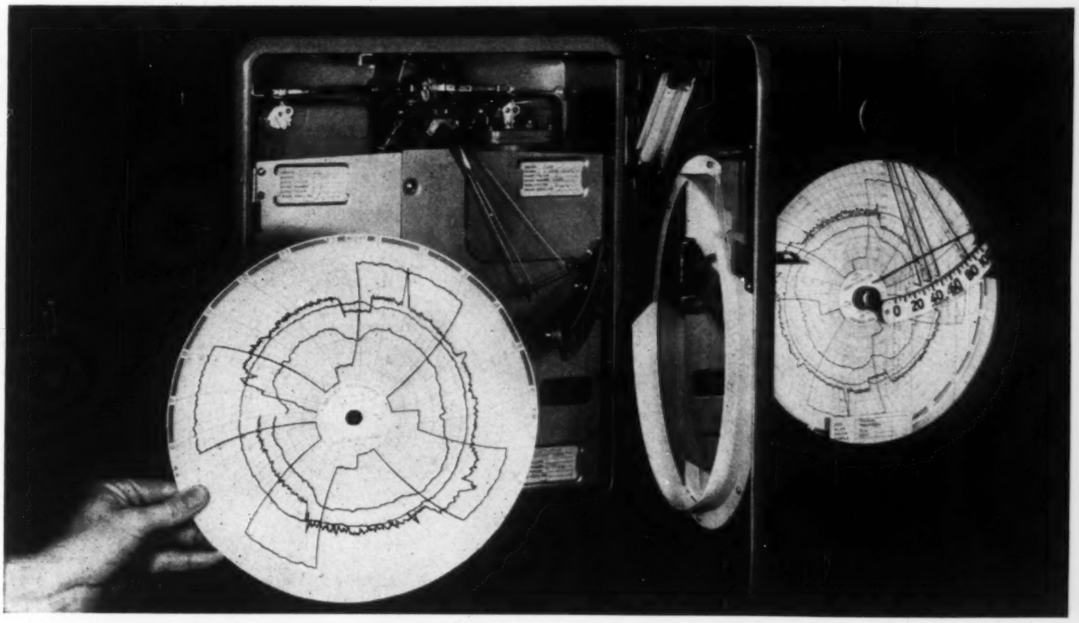
Plan to reduce control valve maintenance costs by sending for Bulletin 5304 Diaphragm Control Valves.

LESLIE CO., 299 GRANT AVENUE • LYNDHURST, NEW JERSEY

LESLIE TRADE MARK **CONTROL VALVES**

"STILL FAR AHEAD IN QUALITY AND PERFORMANCE"

For more information circle 9 on inquiry card.



Faithfully yours -

Clear, Continuous Records without Poisoning . . . on the New Bailey Recorder

★ Faithful chart records of measured variables are the key to a meaningful, dependable analysis of operating trends and conditions. Money spent for more accurate metering, for faster response, is money down the drain—*unless* it's matched with chart records that are equally accurate.

That's why these features of the new Bailey Recorder are important to you:

1. Bailey's exclusive sealed capillary-action inking system maintains continuous flow to the pen tip, and traces sharp, opaque, quick-drying records. "Poisoning" of intersecting records is practically eliminated; no blots or smears during operation or chart changing.

2. Pens are mounted on concentric centers, trace on parallel time arcs only 42/1000″ apart. This simplifies analysis of two or more records.

3. Interchangeable plug-in receiver units permit practically limitless record-grouping combinations.

Write for Product Specification E12-5 and actual chart sample.

P32-1

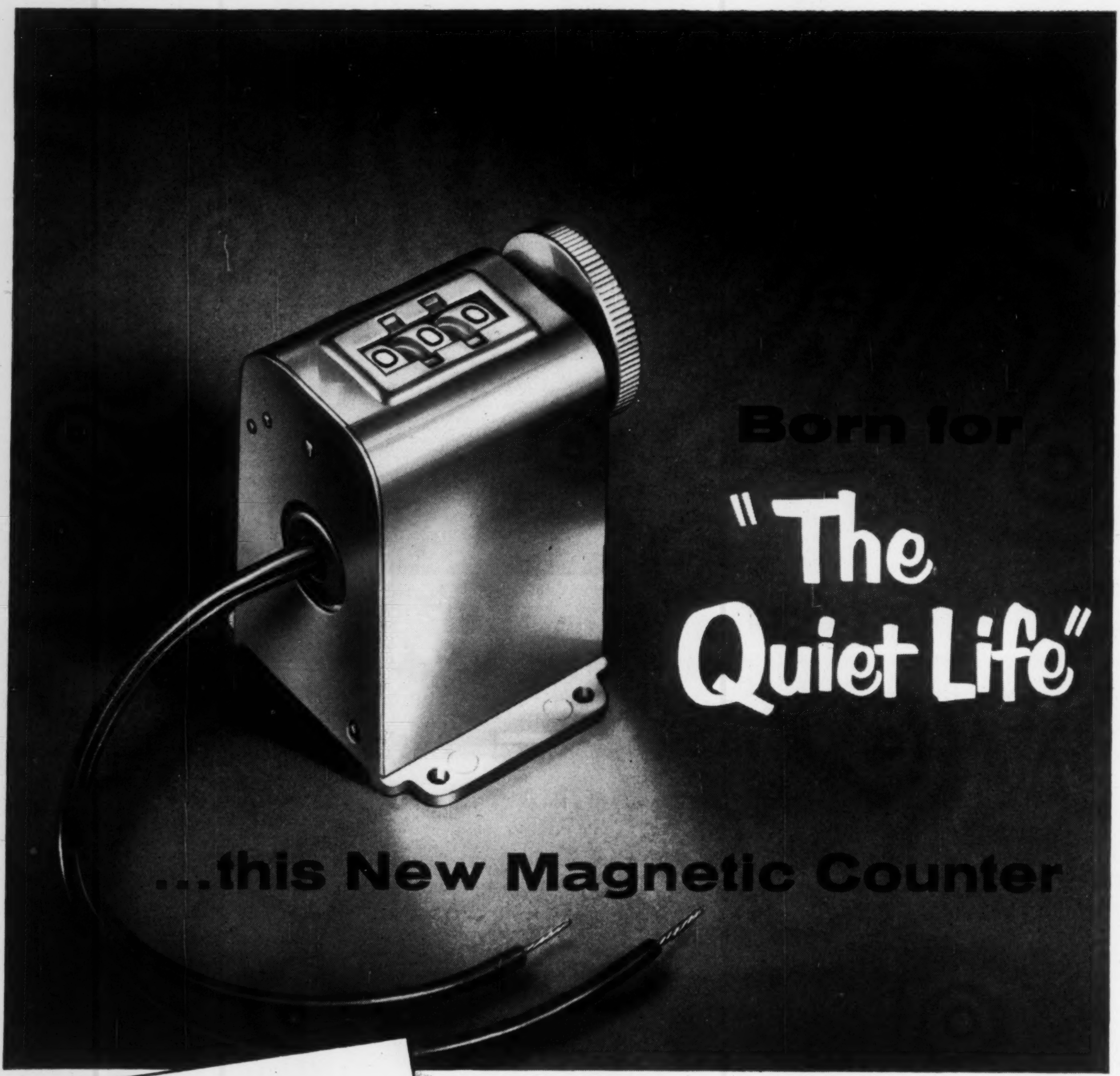
ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

- **Pre-calibrated plug-in receiver units**
- **Up to four pneumatic or electronic receivers —or two receivers and two integrators**
- **Any four variables on one chart—easily read and interpreted**
- **A full year's ink supply at one loading**
- **Faster shipment—from stock**
- **Minimum inventory of parts**
- **Minimum instrument investment for process cycle expansion or alteration**

BAILEY
METER COMPANY
1041 IVANHOE ROAD
CLEVELAND 10, OHIO
Controls for Power and Process

Controls for
TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW · LEVEL
RATIO · DENSITY

For more information circle **10** on inquiry card.



Added Evidence that—

Everyone Can Count on

VEEDER-ROOT

For moderate counting duty, where extreme long life is not required, this new small reset counter is completely reliable. Compact and easily connected, this counter may be actuated by any type of switch, relay or photoelectric unit. Recommended speed is 700 counts per minute. Power consumption is low . . . *and so is the price* . . . but still the same Veeder-Root high quality. So here again is proof that you can count on Veeder-Root for any type of counter . . . electrical, mechanical or manual . . . for any type of duty in any field from atomics to electronics. What do *you* need to count?

Write:

VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT ®

Chicago 6, Ill. • New York 19, N. Y. • Greenville, S. C.
Montreal 2, Canada • Dundee, Scotland
Offices and Agents in Principal Cities

"The Name that Counts"

For more information circle **11** on inquiry card.

New pencil couples and AN thermocouple connectors available through your

HSM

HONEYWELL SUPPLIES MAN

Ask your local Honeywell Supplies Man about these latest additions to the extensive line of Honeywell pyrometer supplies. They could be just what you need for special temperature measuring or testing applications.

New accuracy and serviceability in pencil type thermocouples

Two-wire small-diameter thermocouples just developed by Honeywell give an accuracy of ±5 F from 0 to 1000 F. Their stainless steel tube provides greater durability, and eliminates errors from parasitic emf's. The couples come with general purpose terminal head, or with a weatherproof screw cover head. The small tube, $\frac{3}{16}$" or $\frac{1}{8}$" O.D., fits practically anywhere. Lengths from 6" to 72" are available.

AN connectors simplify temperature test set-ups

Two-wire connectors made to AN specifications, but with Brown part numbers for identification, are the ideal solution to the problem of connecting thermocouples to recorders in permanent or semi-permanent test panels. A complete series of models is available, all with screw type connecting action . . . including box receptacle, cable receptacle, straight plug and cable clamp types.

Your HSM will be glad to give you complete information, and to discuss how the HSM Plan can bring new convenience and economy to all your pyrometer supplies purchases. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA: Write for Pyrometer Supplies Buyers' Guide No. 100-6.**

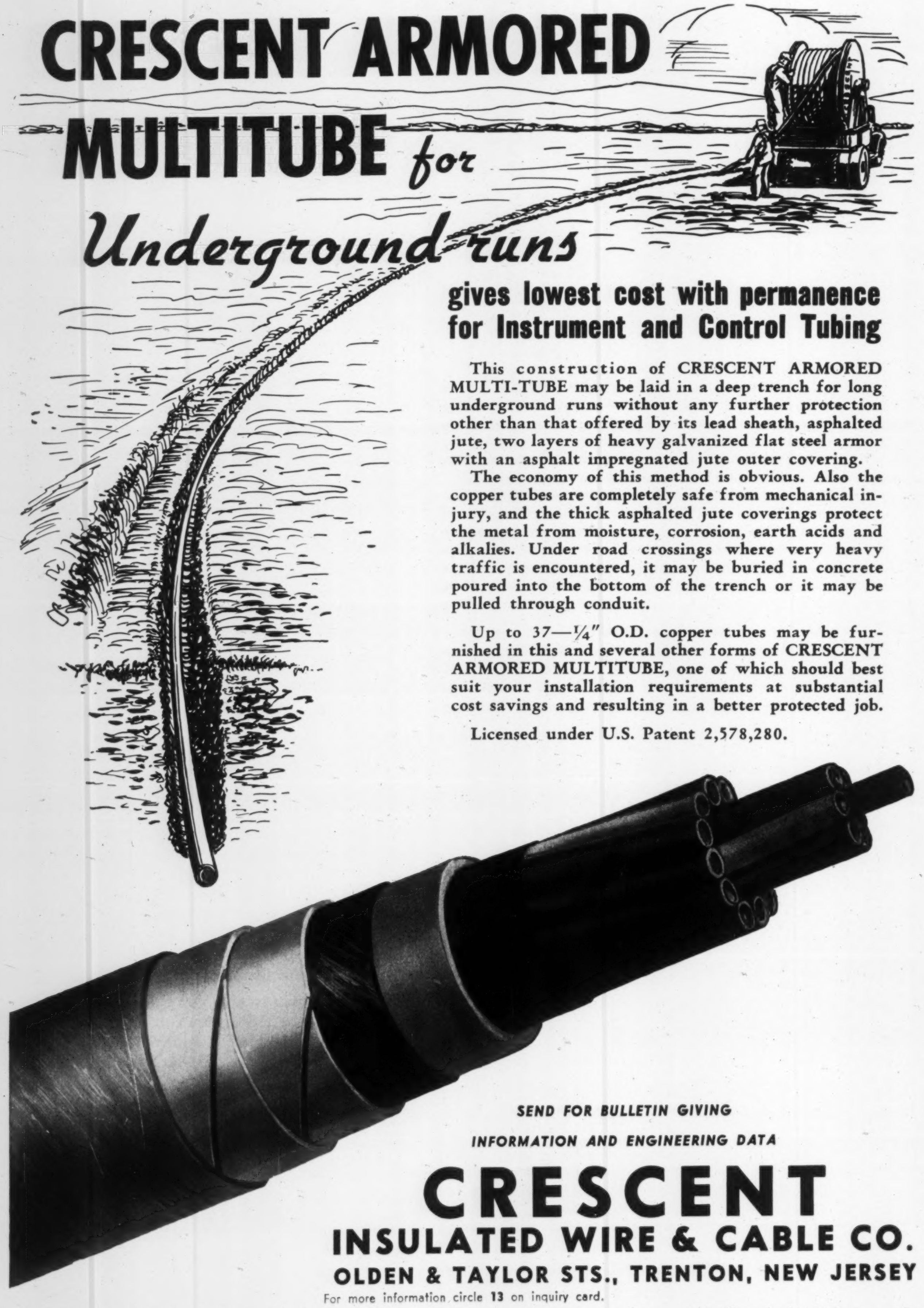
H
HONEYWELL

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls

For more information circle **12** on inquiry card.

CRESCENT ARMORED MULTITUBE *for Underground runs*



gives lowest cost with permanence for Instrument and Control Tubing

This construction of CRESCENT ARMORED MULTI-TUBE may be laid in a deep trench for long underground runs without any further protection other than that offered by its lead sheath, asphalted jute, two layers of heavy galvanized flat steel armor with an asphalt impregnated jute outer covering.

The economy of this method is obvious. Also the copper tubes are completely safe from mechanical injury, and the thick asphalted jute coverings protect the metal from moisture, corrosion, earth acids and alkalies. Under road crossings where very heavy traffic is encountered, it may be buried in concrete poured into the bottom of the trench or it may be pulled through conduit.

Up to 37—¼" O.D. copper tubes may be furnished in this and several other forms of CRESCENT ARMORED MULTITUBE, one of which should best suit your installation requirements at substantial cost savings and resulting in a better protected job.

Licensed under U.S. Patent 2,578,280.

SEND FOR BULLETIN GIVING

INFORMATION AND ENGINEERING DATA

CRESCENT
INSULATED WIRE & CABLE CO.
OLDEN & TAYLOR STS., TRENTON, NEW JERSEY

For more information circle **13** on inquiry card.

Circle **14** on inquiry card. ⟶

NOW! Brush introduces the "Countess"

BRUSH
Countess

9
8
7
6
5
4
3
2
1
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A COMPLETELY DIFFERENT

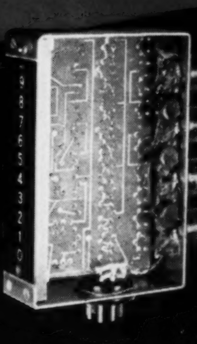
DIGITAL COUNTER

* **LOWER POWER**—This new Digital Counter is the first designed for 150-volt operation—*one-half* the voltage, *one-fourth* the power required for conventional counters. The result is less heat, greater reliability.

* **LOWER COST**—The use of modern printed circuits, plus efficient volume production permits substantial savings. These savings are passed on to you. The *Countess* is the lowest-cost high-quality counter available!

* **VERSATILE READOUT**—Data can be presented visually on neon or drum-dial readouts, or electrically in four-line code or analog stair step. No other counter is so versatile!

The *Countess*—a new idea in Digital Counters—is an ideal choice as a component in your equipment for testing, control, computers, etc. Send now for complete information!



Counter with new printed circuit designs is compact, requires only 1.2 watts. Counter generates one output pulse for each ten input pulses.

This Digital Cycling Counter, incorporating the *Countess*, is used for counting events, measuring frequency, RPM, etc.

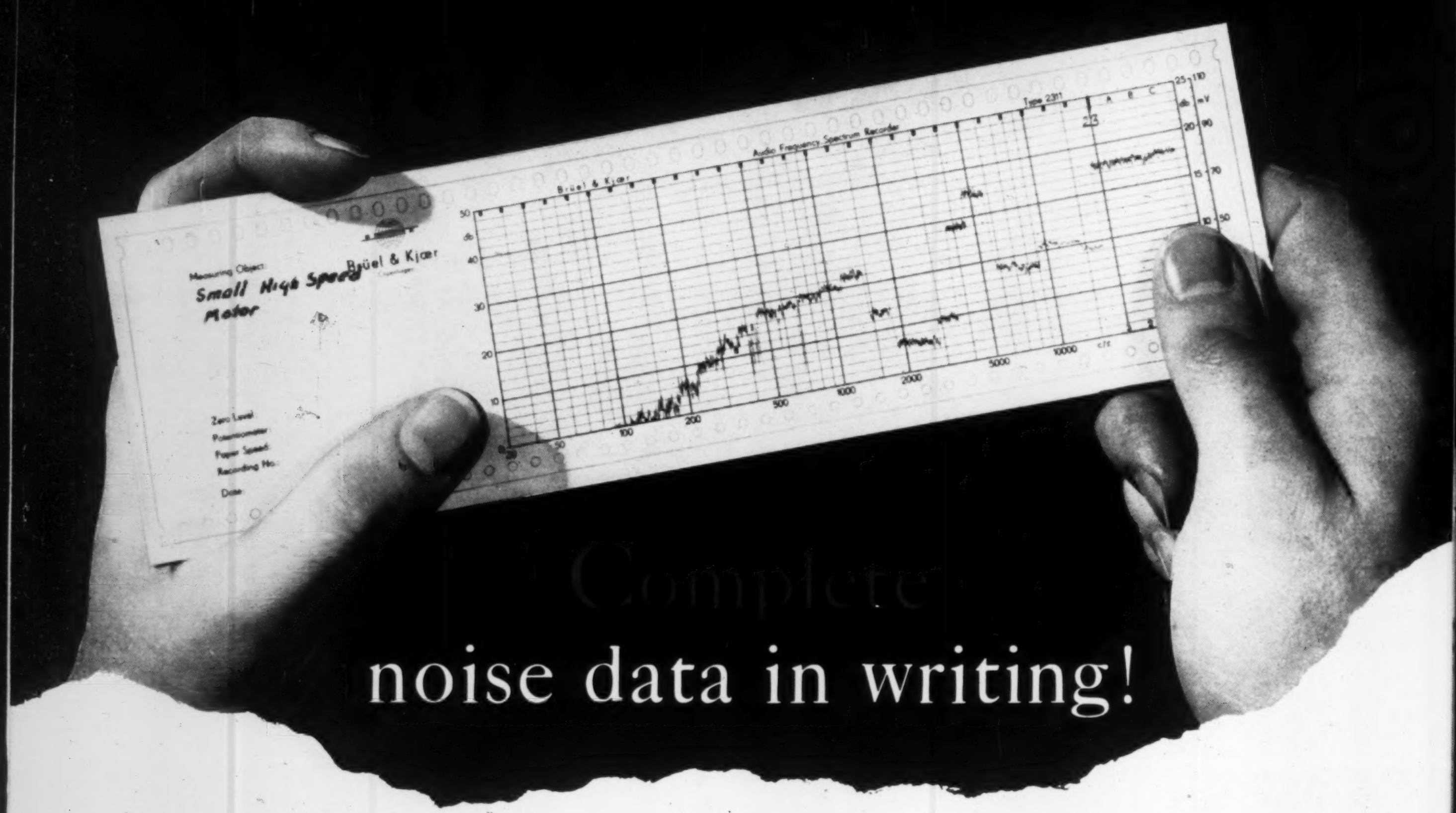
For brochure write Brush Electronics Company, Department A-4, 3405 Perkins Avenue, Cleveland 14, Ohio.

BRUSH ELECTRONICS COMPANY

BRUSH ELECTRONICS

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

Division of
Clevite Corporation



Brush Third-Octave Spectrum Recorder simplifies noise and vibration analysis

This sound analysis and recording system provides a written chart record of noise levels—in ⅓ octave bands. The chart gives you complete and accurate data for noise analysis.

Above is a complete frequency and noise level analysis chart for a small electric motor—recorded in 18 seconds! Thus, the system speeds and simplifies noise studies. The Third-Octave Spectrum Recorder also can operate unattended for 24 hours or more, where long-duration records of factory noise levels are desired.

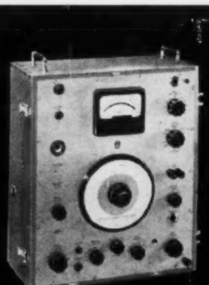
The only recording system of its type that provides narrow frequency band analysis, the Third-Octave Spectrum Recorder is also used in data reduction from magnetic tape, frequency analysis measurements, etc. Write now for complete information.

Third-Octave Spectrum Recorder provides a complete, self-contained system for noise analysis and recording—no extras to buy. Precision microphone and microphone calibration apparatus available. System automatically scans and plots sounds from 35 cycles to 18,000 cycles per second in ⅓ octave steps.

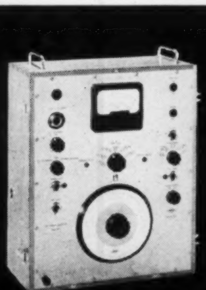
SOUND AND ELECTRO-ACOUSTICAL MEASUREMENTS

Brush offers a completely integrated line of equipment for sound measurement systems. Developed for laboratory use by Bruel & Kjaer, these precision instruments are finding ever broader use throughout industry.

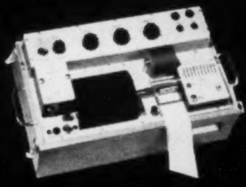
BL-1012	Beat Frequency Oscillator
BL-1502	Deviation Test Bridge
BL-1604	Integration network for Vibration Pickup BL-4304
BL-4304	Vibration Pickup
BL-2002	Heterodyne Voltmeter
BL-2105	Frequency Analyzer
BL-2109	Audio Frequency Spectrometer
BL-2304	Level Recorder
BL-2423	Megohmmeter and D.C. Voltmeter
BL-3423	Megohmmeter High Tension Accessory
BL-4002	Standing Wave Apparatus
BL-4111	Condenser Microphone
BL-4120	Microphone Reciprocity Calibration Apparatus
BL-4708	Automatic Frequency Response Tracer



VERSATILE SIGNAL SOURCE Beat Frequency Oscillator has continuously tuned frequency range, metered output, frequency modulating circuit, variable compression and noiseless oscillator stop switch



MEASURES FREQUENCY COMPONENTS... Audio Frequency Spectrometer measures amplitudes of frequency components in complex AC voltages. A high-gain, precision instrument.



HIGH SPEED RECORDING.. Level Recorder permits high speed recording of variations in level of AC voltages from 20 to 200,000 cycles per second. Simplifies recording noise levels, frequency response curves, etc.

BRUSH ELECTRONICS BRUSH ELECTRONICS **COMPANY**

INDUSTRIAL AND RESEARCH INSTRUMENTS
PIEZOELECTRIC MATERIALS • ACOUSTIC DEVICES
MAGNETIC RECORDING EQUIPMENT AND COMPONENTS

Division of
Clevite Corporation

INSTRUMENTS for SOUND MEASUREMENTS

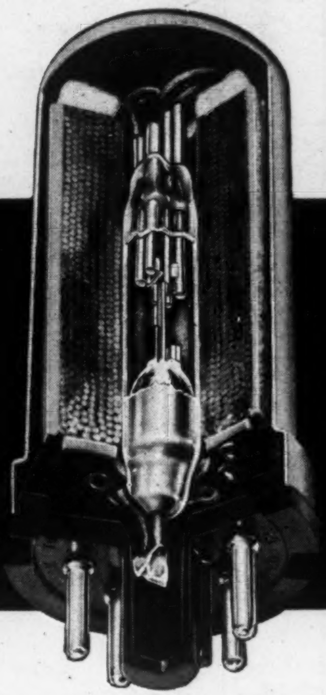
For brochure write Brush Electronics Company, Dept. A-4, 3405 Perkins Avenue, Cleveland 14, Ohio.

A BILLION OPERATIONS

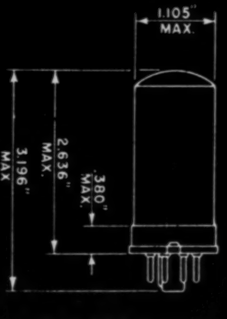
. . . with no maintenance whatsoever

. . . from NEW CLARE

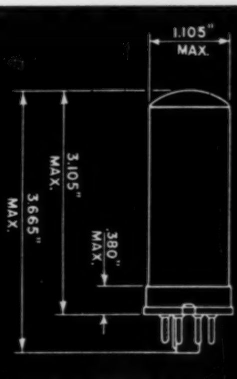
Mercury-Wetted Contact Relays



• Cutaway view showing sealed-in-glass, mercury-wetted contact switch, surrounded by the operating coil and encased in a metal housing mounted on an octal base.



Type HG Relay



Type HGP Relay

CLARE Type HG and HGP Relays are built to meet the exacting requirements for—

Computing machines	Servo-mechanisms
Sorting machines	Relay amplifiers
Tabulating machines	High-speed keying relays
Totalizers	Signaling devices

All kinds of high-speed switching devices

Outstanding features of CLARE Type HG and HGP Relays

ELECTRICAL FEATURES

LONG LIFE: Conservative life expectancy of over a billion operations when operated within ratings.

HIGH SPEED: Give consistent performance at speeds up to 60 operations per second.

HIGH CURRENT—and voltage-handling capacity (up to 5 amperes, and up to 500 volts).

UNIFORMITY: Operating time varies by only about 0.1 millisecond under constant drive conditions.

CHATTER-FREE: Mercury dampens armature vibration and bridges mechanical chatter between metal contact surfaces.

MECHANICAL FEATURES

- Small chassis space required
- Convenient plug-in mounting
- Environment-free
- Tamperproof
- High sensitivity
- Maintenance-free
- No contact wear
- Adjustment cannot change

← Circle 14 on inquiry card.

This first announcement of the new CLARE Mercury-Wetted Contact Relays is of especial importance to designers of high-speed switching machines and devices which demand accuracy and dependability of a high order.

In these relays, with their unique electrical and mechanical stability, you will find exactly the qualities this kind of apparatus requires—

—Long life (over a billion operations)
—High speed (up to 60 operations a second)
—High current- and voltage-handling capacity (up to 5 amperes, and up to 500 volts)
—Bounce- and chatter-free contacts
—Extraordinary uniformity of operation

These distinctive characteristics are achieved by the use of platinum contact surfaces, continuously wetted with mercury by capillary action, and the hermetic sealing of a magnetic switch in a protected glass capsule, filled with pressurized hydrogen.

CLARE Type HG Relays comprise a switch element and an operating coil. CLARE Type HGP Relays are similar but can be factory-adjusted to provide either biased or polarized operating characteristics.

For complete information on the new CLARE Type HG and HGP Mercury-Wetted Contact Relays, contact your nearest CLARE representative or address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois.

Send for CLARE Sales Engineering Bulletin No.120

CLARE RELAYS

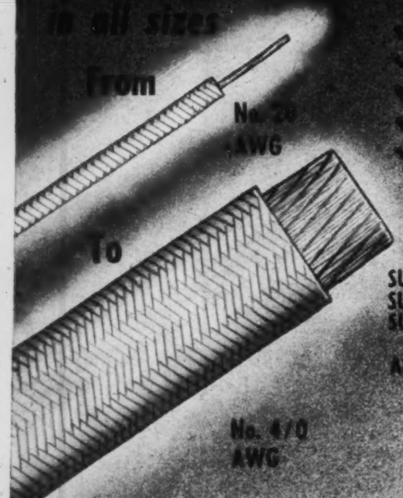
FIRST IN THE INDUSTRIAL FIELD

For more information circle **15** on inquiry card.

LEWIS AIRCRAFT ELECTRICAL CABLE

HIGH TEMPERATURE, MOISTURE AND FIRE RESISTANT!

Combining the . . .



in all sizes From No. 20 AWG To No. 4/0 AWG

- ✓ HIGH TEMPERATURE RESISTANCE OF NICKEL CLAD COPPER CONDUCTORS,
- ✓ ABRASION AND FIRE RESISTANCE OF ASBESTOS,
- ✓ INSULATION VALUE AND HIGH TEMPERATURE RESISTANCE OF GLASS FIBERS,
- ✓ HIGH TEMPERATURE RESISTANCE AND BONDING PROPERTIES OF SILICONE,
- ✓ DIELECTRIC STRENGTH AND SOLVENT RESISTANCE OF TEFLON *

. . . to give the aircraft industry an electrical cable that will withstand continued ambient temperatures over 600 F and still maintain . . .

SUPERIOR . . . WET DIELECTRIC STRENGTH
SUPERIOR . . . ABRASION RESISTANCE
SUPERIOR . . . RESISTANCE TO SOLVENTS, OIL, FUEL, HYDRAULIC FLUID, SALT WATER
ABILITY . . . TO MAINTAIN CIRCUIT INTEGRITY IN AN EMERGENCY OF FIRE FOR SUFFICIENT LENGTH OF TIME TO COMPLETE CORRECTIVE PROCEDURES.

WRITE for complete data on High Temperature Cable to Air Force Specification 32659

THERMOCOUPLE WIRE to the latest Military Specifications

MIL-W-5846 A	CHROMEL-ALUMEL
MIL-W-5845 A	IRON-CONSTANTAN
MIL-W-5908 A	COPPER-CONSTANTAN

MANUFACTURED WITH THE SAME HIGH QUALITY MATERIALS AS OUR HIGH TEMPERATURE CABLE

Available in all classes and types, specify LEWIS thermocouple wire for dependable thermocouple, thermometer installations

* Du Pont trade-mark.

THE LEWIS ENGINEERING CO.

NAUGATUCK, CONNECTICUT

For more information circle **16** on inquiry card.

Trends...

INSTRUMENTS and AUTOMATION

Instruments Publishing Company was first to report (in January, 1954) that 1953 volume of instrument business was $4.2 billion. Recent data (see page 630) indicates 1953 volume exceeded $6 billion. Other publishers and economic bureaus please note: IPC is first with this news; please credit.

Radio-electronics industry annual volume doubled in two years from 4.4 billion in 1952 to $8.8 billion in 1954. Other industries in 1954 report: automobiles—$11 billion; steel—$10 billion; industrial research (private)—$2 billion; research (federal)—$2 billion; capital expenditures by industry in 1954—$27 billion.

Dangerous trend: number of U. S. engineering graduates decreased in 1954 to mere 20,000; contrasted with 50,000 in 1950. Russia has increased engineering graduates from 28,000 in 1950 to 54,000 in 1954 (according to GE survey).

Interest in foreign and Canadian market is growing rapidly. Minneapolis-Honeywell now has $6 million investment in Canada. Watch for increased activity in export on part of American instrument industry. Big news is about to break.

Speakers and editors talking about "manless computer-controlled factories" are aiding labor in demand for Guaranteed Annual Wage. GAW may (or may not) be good for economy—but editors in field of instrumentation should know better than to pin blame for unemployment on automation, which they are unconsciously doing with their superficial generalizations.

Diversified Growth Stock Fund, Inc., of Elizabeth, N. J., has increased holdings in National Research Corp., National Cash Register, Raytheon, Texas Instruments, Sprague Electric, and Westinghouse. Also held are Beckman, CEC, IBM, M-Honeywell, Telecomputing, and other "growth" stocks.

Research Institute of America polled 1000 companies with question how soon will automation be in extensive use in your industry? Answers: Now—16%; before 1964—23%; never—34%. Smaller companies reported less activity in automation than larger companies.

Atomic power may supply 50% of all new electric power installation by 1976, says R. J. Cordiner, President, GE. Coal, gas, and oil market also will expand due to electric-power demand for automation.

Trends at IRE Show: Increased emphasis on components of all types, and on magnetic-tape recording of data, digitizers, and computers. Reeves and Beckman revealed new analog computers; Wang Laboratories showed an exciting new digital computer with analog programming. Trend is to increased use of graphic (printed) circuitry in all electronic equipment. First transistorized consumer product (Regency Radio with TI transistors) is capturing portable radio market.

News . . .

Principles and Applications

INSTRUMENTS and AUTOMATION

Tape-controlled Boring Machine

NEW YORK, N. Y.—The punched-tape principle of automatic operation has been applied to a precision boring machine used for production of instrument gear trains (boring shaft holes in gear plates).

A system worked out by Minneapolis-Honeywell Regulator Co. includes a standard four-spindle Excello precision boring machine modified with built-in electronic controls and circuitry and a tape "reader" housed in a specially-built control cabinet. John Rudolf, head of Honeywell's automation section, said this represents the first application of tape-controlled principles to a precision boring machine.

Hold coordinates and feed instructions are punched on the tape by a perforating machine similar to a typewriter. Electronic signals from the tape regulate the linear travel of the boring machine's hydraulic cross slide and the rotary motion of a specially-designed holding fixture mounted on the cross slide.

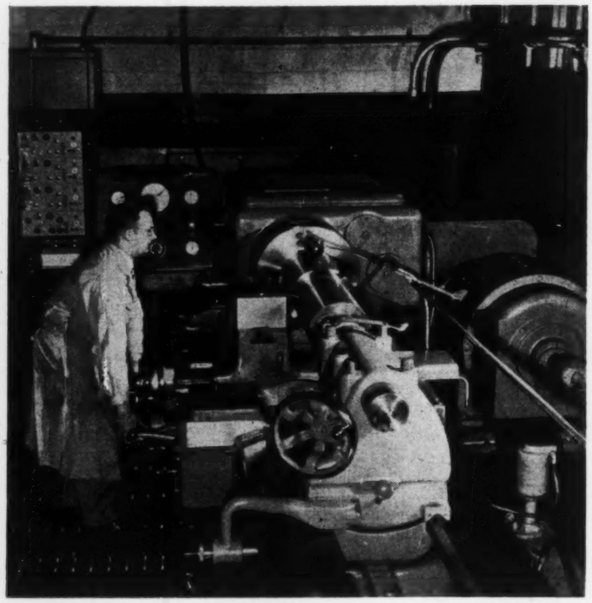
"Early studies indicate that it is ideally suited for medium-sized production lots," Rudolf said. "Tooling and set-up costs are substantially lower than for punch press piercing dies or drill ream jigs and operating costs are less than for jig borers."

Tape preparation requires approximately five minutes per hold and complete changeover from one part to another can be accomplished in about 30 minutes. The machine is accurate to plus or minus 0.0005 inch.

Operator in foreground is using the tape perforator. Tape reader and control cabinet is at left. Boring machine is at upper right.

Lathe Controller

DETROIT, MICH.—Electronic-feedback control system maintains speed with less than 1 percent variation when full load is applied on this new special 125-hp, 32-inch LeBlond lathe, installed recently in the machinability lab of Carboloy Department of General Electric Company, Detroit. The lathe will be used to test machinability of materials with various grades of cemented-carbide tools. Drive unit of the 12-ton machine can deliver 200 horsepower for long periods, will supply up to 350 horsepower before quitting. Complete G-E electronic instrumentation includes high and low horsepower meter, overload indicator, work-riding tachometer for surface speed, infinitely variable speeds from 4 to 1400 rpm.



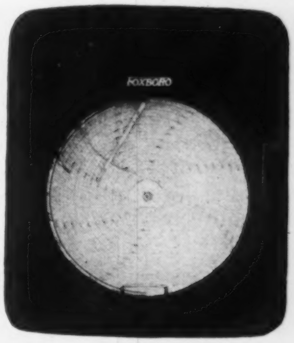
Data Processing

VAN NUYS, CALIF.—Marquardt Aircraft Company, Van Nuys, California, has installed a high-speed data processing system that will reduce by as much as 65 percent the time lag in gaining test results on ram-jet engines. The $160,000 electronic unit, manufactured by the Systems Division of Consolidated Engineering Corporation, Pasadena, California, converts 400 readings to digital form in one second; information channels can be sampled at rates up to 1600 readings a second, according to Kennett W. Patrick, Systems Division director at Consolidated. The entire system operates with an overall error of less than 1 percent.

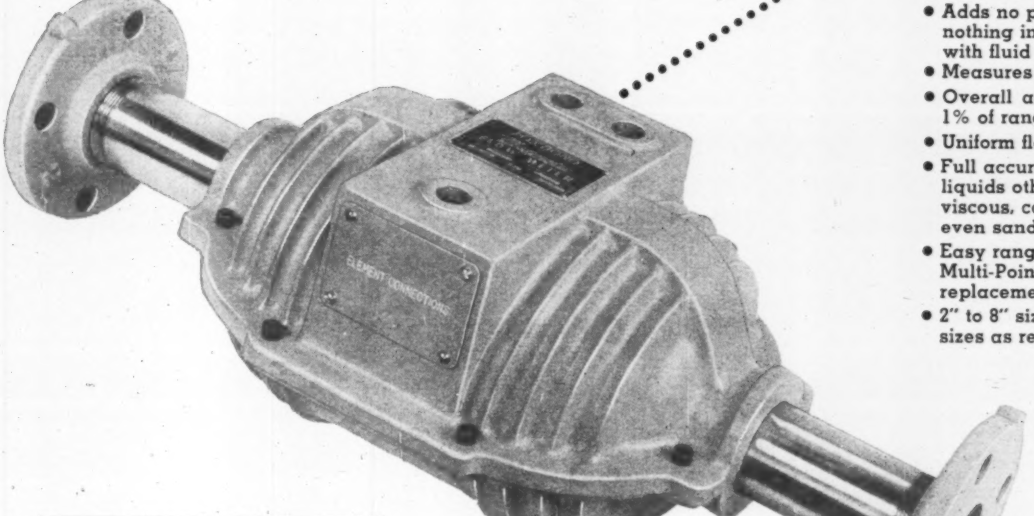
Automation School

PHILADELPHIA, PA.—Some 315 employes, representing 204 companies in 33 states and 9 foreign nations,

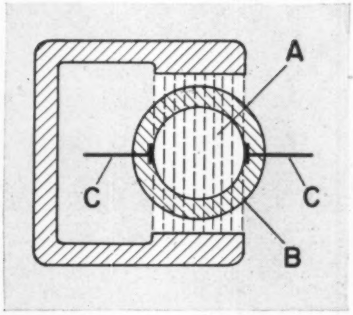
NEW! a flow meter with no flow restrictions!



- Adds no pressure drop — nothing inside pipe to interfere with fluid flow.
- Measures fluid velocity directly.
- Overall accuracy better than 1% of range over entire scale.
- Uniform flow scale.
- Full accuracy sustained even on liquids other meters can't handle: viscous, corrosive, or pulpy — even sand-water slurries.
- Easy range change — either by Multi-Point Switch or range coil replacement, as preferred.
- 2" to 8" sizes standard — larger sizes as required.



FOXBORO MAGNETIC FLOW METER



SIMPLE, TROUBLEFREE, OPERATION

The Foxboro Magnetic Flow Meter operates on the same principle as a power generator. A magnetic field (A) is maintained through a standard pipe section (B) of stainless steel or other non-magnetic material. This pipe section is lined with Kel-F® or other insulating material. Liquid passing through pipe acts as moving conductor, generating an electric voltage which varies in proportion to liquid's average velocity. Flush electrodes (C) in pipe wall "pick up" this voltage which is recorded in desired flow units by Dynalog Electronic Recorder or Controller.

This premium-performance meter measures *magnetically* the flow rate of virtually any liquid except hydrocarbons. It completely ignores such common metering headaches as turbulence, suspended solids, and variations in conductivity, density, and viscosity. It even measures reversing flows.

Installation is simple. The magnetic spool piece connects into the line like any equivalent length of pipe — no seals, purges, meter runs, or straightening vanes required. Connects by 2-conductor cable to remote Dynalog Electronic Flow Recorder.

Maintenance is practically eliminated. There are no pressure taps to become plugged or frozen, no working parts to foul.

Foxboro Magnetic Flow Meters are already in use on such widely different liquids as beer, sand-and-water, rosin size, rock-and-acid slurry, viscose, and highly corrosive liquid detergent. Find out how this precise, troublefree flow meter can help *your* processing. Write for complete details.

THE FOXBORO COMPANY, 464 NEPONSET AVENUE, FOXBORO, MASS., U. S. A.

FOXBORO
REG U S PAT OFF

Foremost in FLOW METERING

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

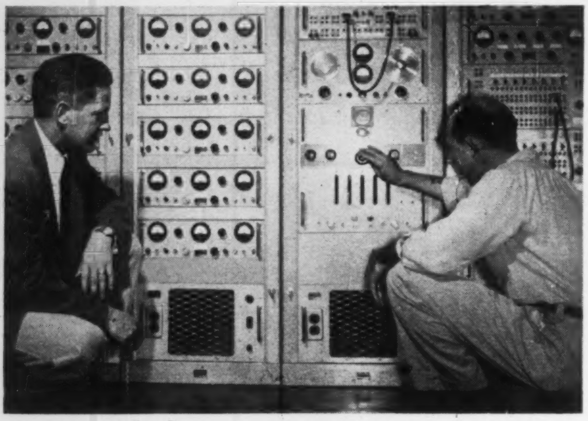
For more information circle **17** on inquiry card.

were graduated from Minneapolis-Honeywell's Industrial Division Training School in Philadelphia in 1954, M. J. Ladden, director of the school, has announced. Courses covered instruction in the application of electric, pneumatic and electronic automatic recording, measuring and controlling instruments, including their repair and maintenance. The courses lasted from two to six weeks.

Flight-test-data Reduction

DALLAS, TEXAS.—Computing flight test data from oscillograph records, ordinarily a time-consuming, laborious process, has been speeded up ten times by a semiautomatic computer developed by Chance Vought Aircraft.

The company has filed for a patent on the data computer, five of which have been given a thorough tryout. Two sizes of the computers were produced, one capable of handling eight traces and the larger one 20.



An oscillograph record consists of a rolled strip of paper along which are the traces obtained when a test plane goes through flight maneuvers. The computer has three assemblies, a position-sensitive tracing board, an analog computer and a graphic recorder. Oscillograph data is fed into the machine by following the outline of each trace on the roll with a special tracing head.

Instantly processing the input of raw data, the computer automatically plots a complete time history of each function analyzed on a chart drawn to the time and trace-amplitude scales most favorable for clear presentation. The time scale can be expanded or contracted, or tracings widely separated on the oscillogram may be placed next to each other on the plotted chart.

The oscillograph computer has been licensed to Century Geophysical Corp., Tulsa 10, Oklahoma. The complete data-reduction system is being considered for licensing. Write to Mr. A. L. Schoeni, Chance Vought Aircraft, Inc., P. O. Box 5907, Dallas, Texas.

Columbia University Research

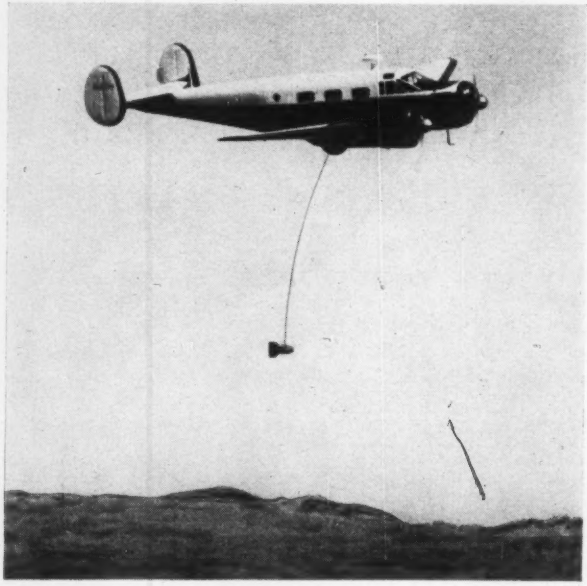
NEW YORK, N. Y.—In the 1955 Annual report "Columbia Research News in Engineering and Science," a report is given on the development of "Maser," or "Microwave Amplification by Stimulated Emission of Radiation." This is a device using the molecular motion of ammonia molecules in an electrostatic field for either oscillation (as in an "ammonia clock") or microwave amplifier with noise level of practically zero db. Possible applications of Maser include frequency standard, high-resolution spectroscope, or preamplifier of sensitivity greater than existing electronic ones.

Another important development reported is that of a hot-wire thermal-conductivity cell that eliminates radiation-error completely by adding a small 60-cycle a-c current to the basic d-c current heating the wire. Gas around the wire causes a phase lag in the a-c heating cycle, producing minute 2nd and 3rd harmonics of the fundamental ac. The lag of harmonic behind fundamental, which indicates the thermal conductivity of the gas, is shown to be unaffected by radiation.

Earth's-field Magnetometer

PASADENA, CALIF.—Exclusive world-wide rights for the Varian earth's-field Magnetometer have been granted to Hycon Aerial Surveys, Pasadena 8, Calif.

The Varian Magnetometer operates on the principle of nuclear magnetic resonance. It uses hydrogen nuclei to record minute changes of the earth's magnetic field, which in turn can indicate the presence of minerals or petroleum deposits. The magnetometer is simple to build and maintain and it does not require gyroscopic stabilization (for absolute readings of total field). The "bird" is little more than a jar of water with a coil wrapped around it.



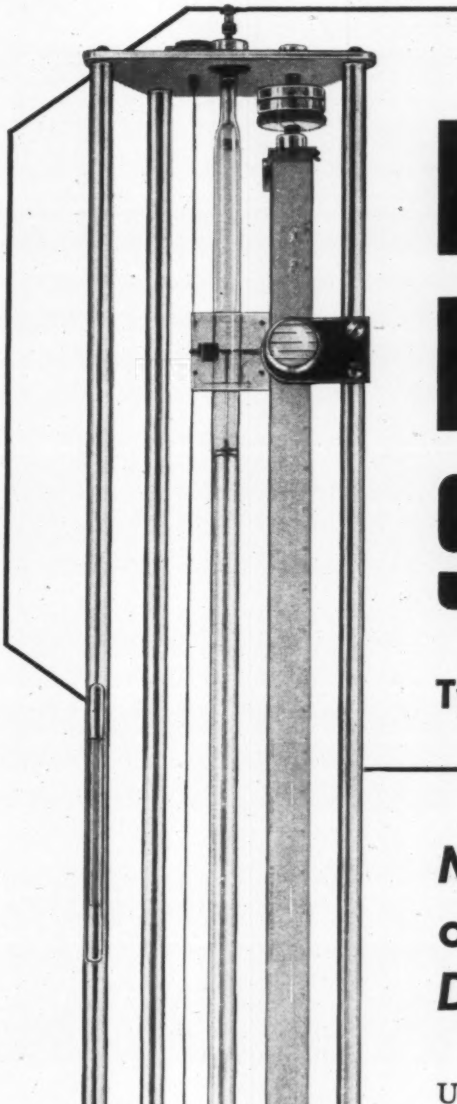
Semiconduction in Liquids

PITTSBURGH, PA.—A liquid has been found that behaves electrically like a solid semiconductor.

An example of semiconductor in a solid is the transistor. The transistor, made of solids like germanium or silicon, conducts electronically, (rather than ionically, as in a battery) and the amount of conductance *increases* with temperature.

This same phenomenon of semiconduction has been found in liquids—molten metallic sulfides—at Carnegie Institute of Technology Metals Research Laboratory, by Drs. G. M. Pound and Gerhard Derge.

In ordinary salts such as sodium chloride, either molten or in a water solution, electrical current is carried by ions, as in a battery. Exploring less familiar liquids such as those used in metallurgical processes, the Carnegie Tech professors discovered that molten liquid sulphides, unlike



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Used interchangeably as a Barometer or Differential Pressure Manometer.

Range: 0 to 800 mm of Hg.
0 to 31.5 in Hg. or in any other desired pressure unit of equivalent range.

The magnetic vernier reads to 0.01 mm or 0.005 in. of mercury with an accuracy of 1 part in 5000 over the full range.

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MOST COMPACT
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HERMETICALLY SEALED

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes. • Circuits: *SPST only*—normally open or normally closed.

AMPERITE DELAY RELAY

STANDARD

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from —55° to +70°C. Heaters consume approximately 2 W. and may be operated continuously. The units are *most compact, rugged, explosion-proof, long-lived,* and — *very inexpensive!*
TYPES: Standard Radio Octal, and 9-Pin Miniature.

PROBLEM? Send for Bulletin No. TR-81

Also — a new line of **Amperite Differential Relays** — may be used for *automatic overload, over-voltage, under-voltage or under-current protection.*

MINIATURE

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- Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp.).
- For currents of 60 ma. to 5 amps. *Operates on A.C., D.C., or Pulsating Current.*
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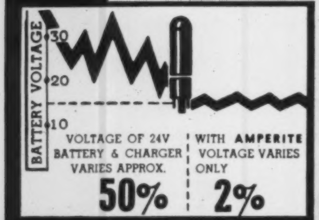
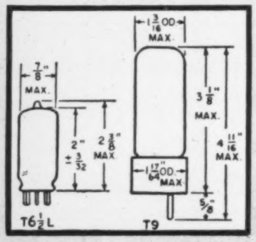




Write for 4-page Technical Bulletin No. AB-51

AMPERITE CO., Inc.
561 Broadway, New York 12, N. Y.
In Canada: Atlas Radio Corp., Ltd., 560 King St. W. Toronto 2B

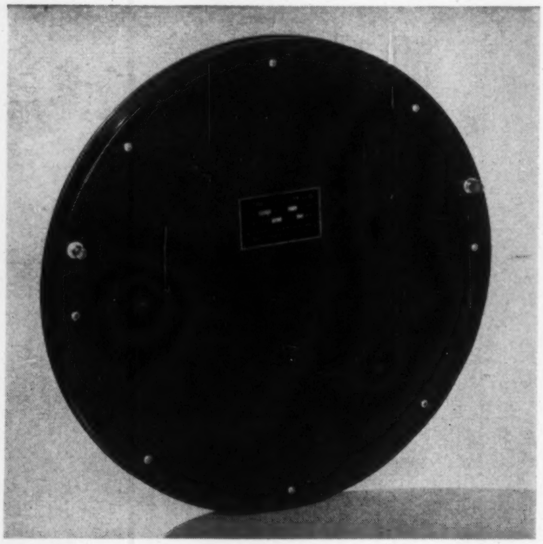
For more information circle **19** on inquiry card.

aqueous solutions or molten ionic salts, behaved like semiconductors. Instead of conducting electricity by the transport of charged atoms (ionically), it conducted electricity by the flow of electrons, as in an ordinary wire. But unlike ordinary metals, the conductance increased with temperature.

Existing theories on the nature of semiconductance cannot account for the new discovery since they apply exclusively to solids such as the transistor, and not to liquids where the atoms are in a state of disorder. This discovery may provide a new tool for probing the mysteries of liquid structure.

World's Longest Quartz Delay Line

WEST HARTFORD, CONN.—Andersen Laboratories, Inc., West Hartford, was recently called upon to develop and manufacture a 4100-microsecond solid untrasonic delay line, the longest solid line ever made (for moving-target-indicator radar application). Producing a delay time equivalent to well over 300 nautical miles of radar range, the line is made of fused quartz. Carrier frequency is 8 megacycles; Bandwidth (3 db), exceeds 2 megacycles. Andersen reports that operation of solid ultrasonic delay lines of this length at higher carrier frequencies and greater bandwidths is possible.



Cathode-emission Tracer

WASHINGTON, D. C.—A cathode emission tracer developed by L. A. Marzetta of the National Bureau of Standards provides a rapid, convenient method for measuring and evaluating the performance of thermionic cathodes. The new instrument automatically produces a calibrated plot of the emission characteristics of the cathode of a diode on the screen of a cathode-ray oscilloscope. A "2/3-power network" is incorporated into the system and may be used at the option of the operator for linearizing the plot. Negligible heat is contributed to the diode under test since the tube is subjected to only a 10- or 100-microsecond pulse at rates of either 5 or 30 cps. Provision is made for instantaneous plate currents as high as 10 amperes or for

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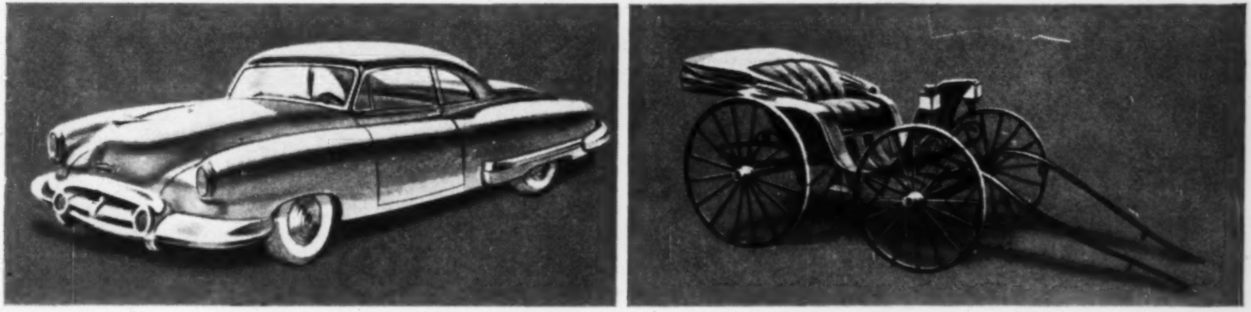

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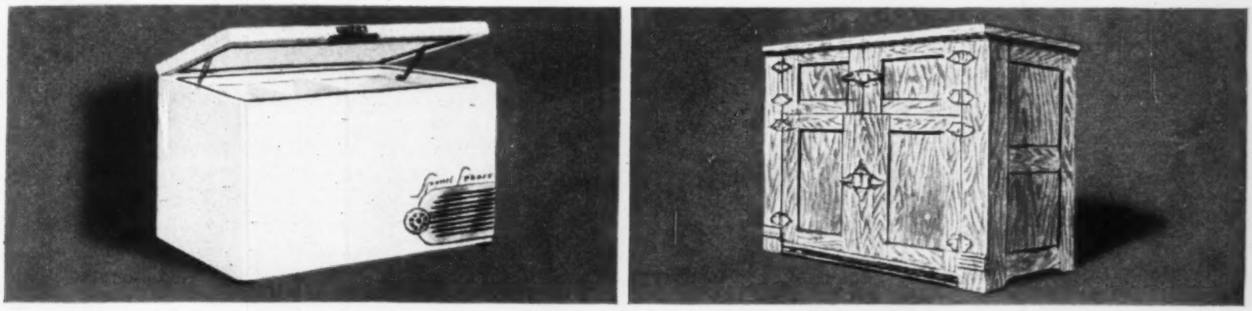

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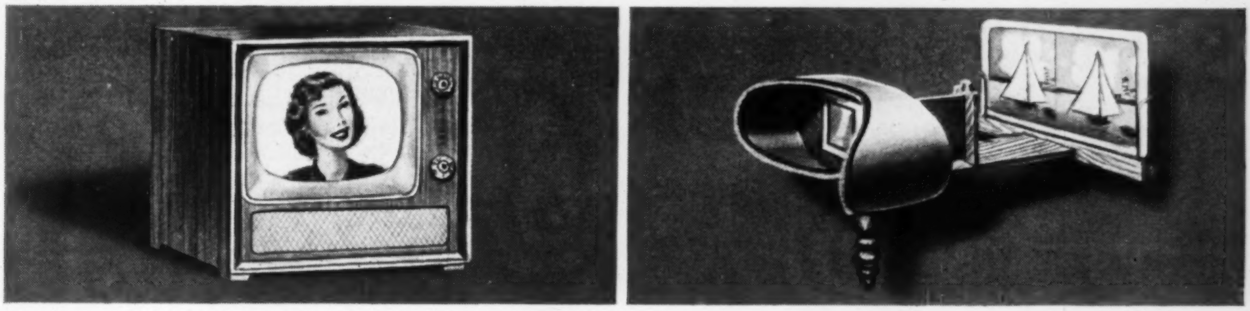

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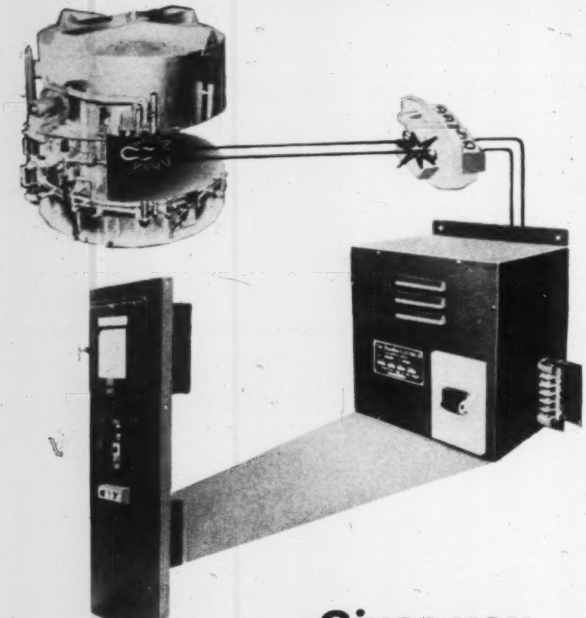

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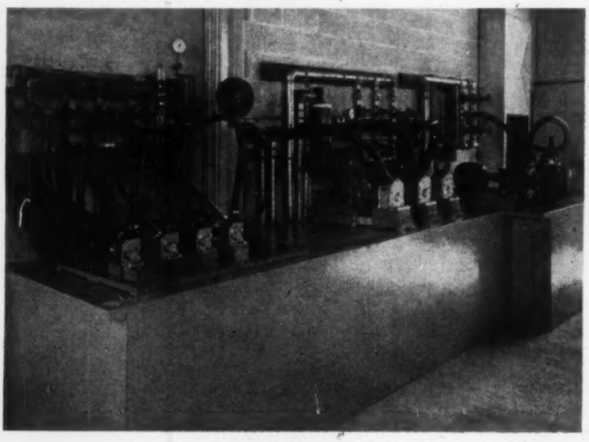
plate voltages up to 5000 volts, although these limiting values are not available simultaneously.

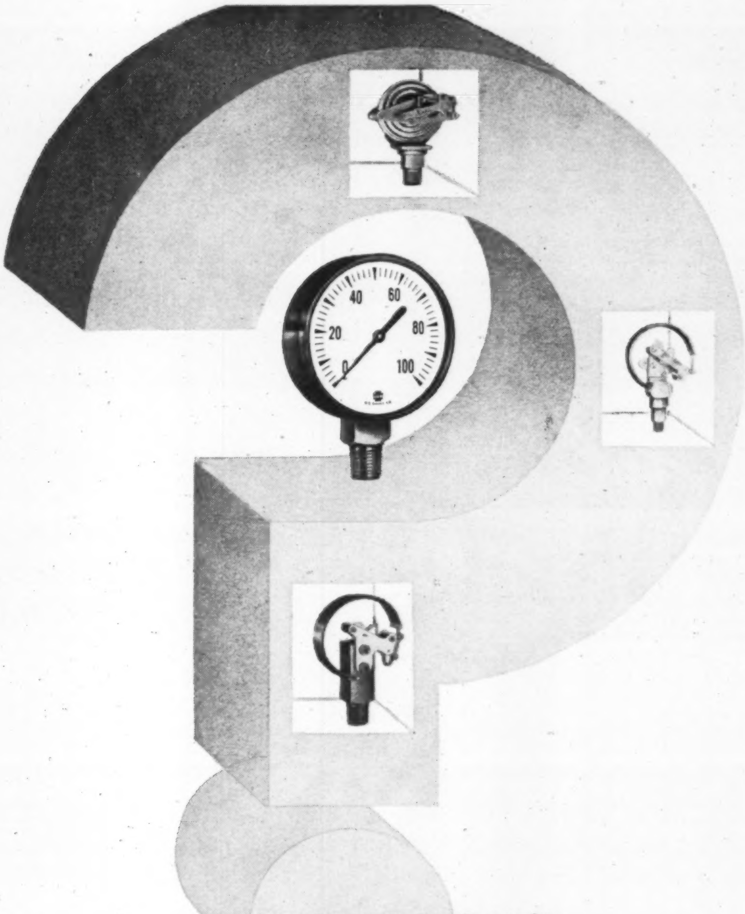
Past methods of obtaining emission data have usually been based on two alternative procedures. In one system, a continuous current is applied to the test diode at selected amplitudes. This system has the disadvantage of requiring a water-cooled anode because of the large steady-state power dissipation. In the second method, current is applied intermittently in short rectangular pulses. Unless operated at a low duty cycle, however, the rectangular pulse system contributes heating to the diode which interferes with planned aging of the tube. The new NBS instrument overcomes these defects.

The instrument also provides a round-dot calibrate marker whose position can be manually controlled. Another convenient feature of the NBS cathode-emission tracer is a special network capable of linearizing a tube characteristic in which the plate current varies as the three-halves power of the plate voltage. The special network uses a series of germanium diodes, each biased to a different voltage level. As the instantaneous input voltage increases, successively more diodes become conductive. The linearizing action is achieved through the resulting variation in impedance.

Pump Test Stand

HILLSIDE, N. J.—This test stand checks ten Vanton "Flex-I-Liner" pumps simultaneously at the Vanton Pump & Equipment Corp., Hillside, N. J. The stand provides for testing of essentially custom-built pumps and gives individual performance reports to the user. The pump design is such that appropriate body block and flexible liner is





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There may very well be, because USG manufactures and stocks more than 200,000 standard gauges and a complete line of gauge components to meet practically every pressure sensing and indicating requirement.

Chances are that, with slight modification, a stock gauge will fulfill your very needs . . . eliminating the expense of special gauge design, engineering and production. USG's special background, experience and resources are ready to assist you with all problems relating to gauges or other pressure actuated devices.

A call to your nearest USG District Office, or, a letter to us at Sellersville is all that you need to determine whether we can supply a "standard" from stock . . . or, whether your application requires a "special"

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United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Penna.

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USG'S RESOURCES HELP DESIGN ENGINEERS MATCH SPECIFICATIONS

Performance and price are two factors every design engineer must consider carefully when specifying gauges.

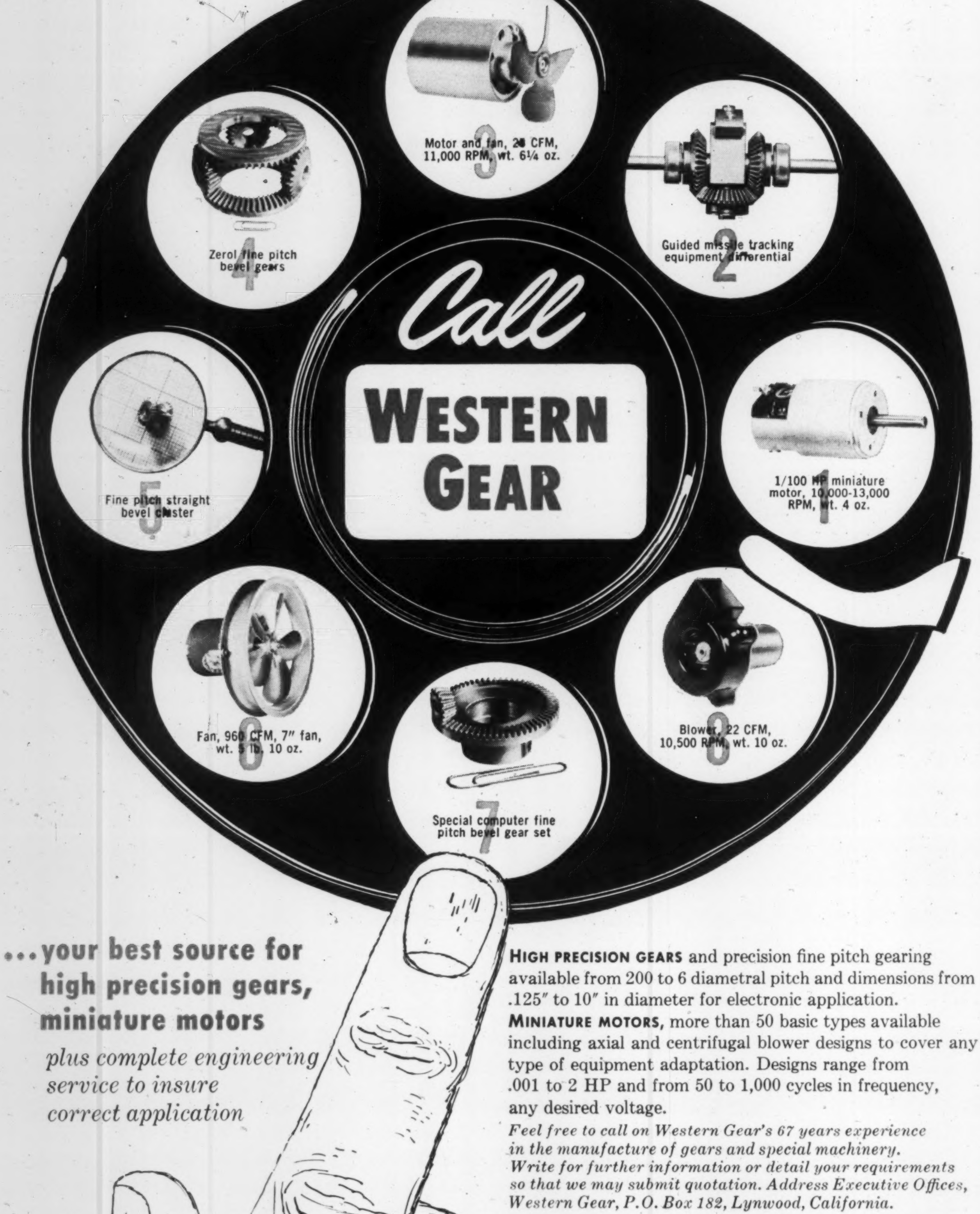
Most engineers know of USG's record of leadership in gauge design and precision engineering—for over 50 years USG has been designing and producing gauges for more Original Equipment Manufacturers than any other instrument company in the world.

Many engineers don't know, however, that USG maintains the world's largest stock of gauge components to meet practically any pressure sensing device or pressure actuator application. These components are stocked by USG *specifically to eliminate expensive special production.*

In addition to the components for special gauge designs, USG inventories over 200,000 standard gauges in a variety of types, sizes and ranges for practically every industry application. Many stock gauges carried by USG are expensive special production items with other gauge manufacturers.

USG provides highest quality gauges at competitive prices because its facilities are economically integrated for large volume, quality controlled production. Gauge for gauge—in every application and classification—*in every price class*—USG has more to offer than any other make!

Above, a portion of USG's Research Laboratory. Here constant testing of materials under customer operating conditions assures optimum efficiency and long gauge life.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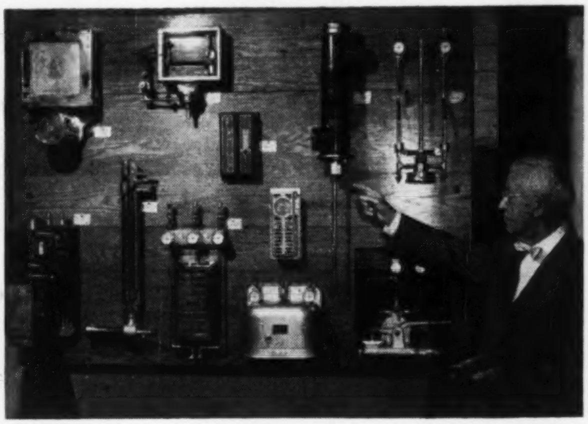
selected for each application, and each pump is individually assembled.

The test stand provides for controlled flow from 0.2 to 150 gpm, with precision flow measurement. Accessories duplicate any flow condition that can be met in service.

Historic Instruments

Logan Lewis, Vice President of the Carrier Corp. (and Past Pres. A.S.R.E.) shows—especially for *Instruments and Automation*—early air-conditioning control systems designed by the late Willis H. Carrier more than 30 years ago, before the Carrier Corp. decided to buy from instrument companies.



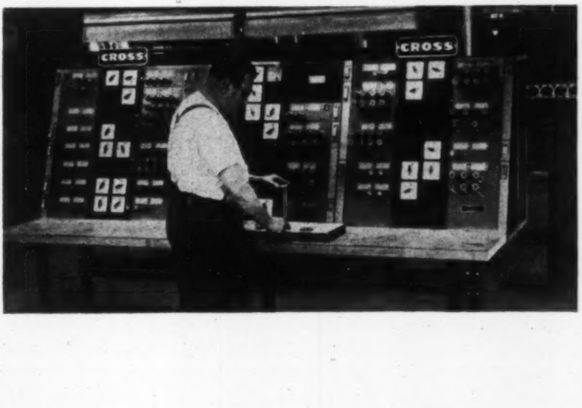
Peltier-effect Refrigeration

NEW YORK, N. Y.—RCA Laboratories reports that the Peltier effect, known since 1834, has been used successfully (but not yet economically) as a basic cooling or refrigerating technique. The well-known Peltier effect refers to the heating or cooling effect that occurs at the junction of two dissimilar metals when a current is passed through the junction. The direction of current determines whether the junction is heated or cooled.

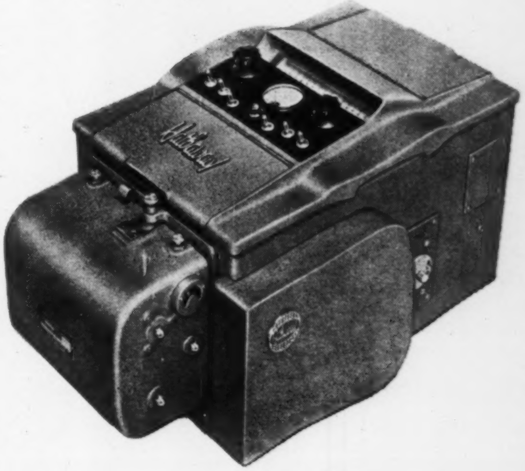
The "electronic refrigerator" uses several hundred junctions of alloys of copper and zinc, and a current of about 25 amperes at 15 or 20 volts. A trickle of tap water is used to remove evolved heat.

Sectionized Automation

DETROIT, MICH.—To minimize prodution losses during periods of downtime, The Cross Company, Detroit, Michigan, has announced the development of "Sectionized Automation". This new advancement is based on the di-



VERSATILE



Hathaway NEW S14-E
OSCILLOGRAPH

Why is versatility important in an oscillograph ... primarily because it reduces instrument investment.

The Hathaway New S14-E is designed to be versatile. Investment in additional equipment is rarely needed—because the S14-E can be readily adapted for many different kinds of recording. The S14-E is a high quality, general-purpose oscillograph available with an unusually wide assortment of standard accessories and galvanometers.

The versatility and low price of the Hathaway S14 have established it, over the years, as a "standard" oscillograph in large laboratories, a "first" oscillograph in small laboratories.

Write for Bulletin 2-D1-H

SPECIFICATIONS

Size: 24 x 13 x 14 inches
Weight: 60 pounds
Channels: To 24
Chart Size: 6 inches x 100 or 200 feet; 6 inches x 15 inches
Chart Speed: 1/10 to 600 inches per second
Chart Speed Change: Standard quick-change transmission (*as illustrated*), or NEW continuously-variable transmission
Galvanometers: Sensitivities to 30,000 mm per ma. per meter; frequencies to 10,000 cps; single and multi-phase watt galvanometers
Power: 115 volts, 50-60 cycles; 12 or 24 volt d-c models available on special order
Case: Walnut or NEW light aluminum; NEW top panel provides greater visibility
Optical System: Individually controlled galvanometer trace width
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AVAILABLE ACCESSORIES

Synchronous time line markers, giving 10, 1, 1/10, and 1/100 second time lines (tenth lines heavier)
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Automatic recording attachments
High-speed shutter and drum for fast recording
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PORTABLE RECORDING THERMOMETER No. 6025 designed for carrying from one location to another. Convenient ranges up to 180° F. Available with 12, 24 hour or 7 day chart drive.

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Adjustable Form Dial Indicating Thermometers with separable socket. Can be quickly adjusted to any angle.

Remote Reading Dial Thermometers, Mercury actuated, with separable socket. Panel or flush mounting.

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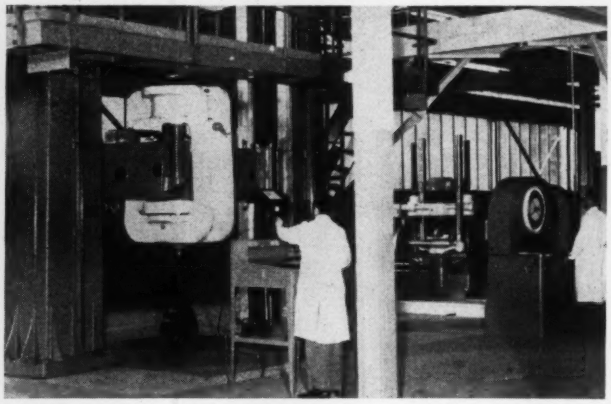
vision of a machine into sections to permit shutting down some of the operations without interrupting the production of others.

Sectionized Automation is being introduced on a new "Transfer-matic" which is 350 feet long and performs 555 operations on V-8 cylinder blocks. It does all of the drilling, chamfering, tapping, camshaft boring and miscellaneous milling on these parts at the rate of 100 pieces per hour. More than 100 pieces are in process simultaneously. The only direct labor is the operator at Station 1 who positions the parts and initiates the cycle by push-button. From there on, the blocks are transferred, positioned. machined and inspected automatically in 104 stations.

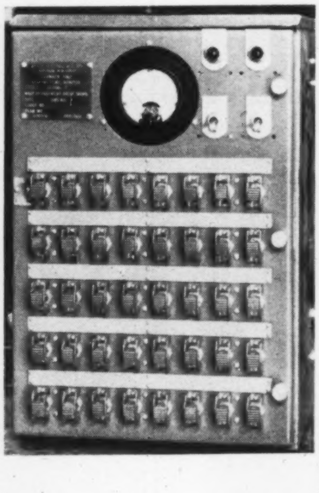
Universal Tester

CLEVELAND, OHIO.—Central feature of the new $1,000,000 Technical Center of National Malleable and Steel Castings Company, Cleveland, Ohio, is a new Baldwin-Lima-Hamilton Corporation testing machine of 1,000,000-lb. capacity with the largest clearance between columns ever built in a machine of this capacity. Its 10-ft. clearance between columns, maximum vertical opening of 19 ft., and 60-ft. base structure indicate the possible size of structures that can be subjected to test loads.



The new machine is used to conduct design tests of railroad car truck side frames and bolsters, design tests of couplers, yokes, draft gears, journal boxes, as well as any other parts or devices made by the company. In the illustration a dynamometer coupler is calibrated in compression.

Ship Bearing Monitor

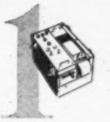


WASHINGTON, D. C.—The Bureau of Ships, Navy Department, uses this Bogue Continuous Bearing Temperature Monitor system. This system enables the operator to maintain a continous and automatic watch on bearing temperatures throughout the ship in which it is installed. Shown is the Scanner Unit. The equipment is made by Bogue Electric Mfg. Co., Paterson, N. J.

now SANBORN

8 *and* 6 CHANNEL "150" SERIES OSCILLOGRAPHIC RECORDING SYSTEMS

in addition to



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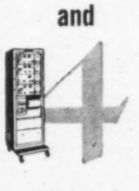


4

Channel Models

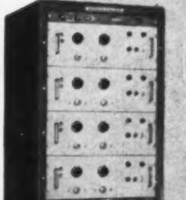
These new additions to the "150 family" follow the original "150" design concept which permits rapid change-over from one set of recording requirements to another by means of interchangeable, plug-in type preamplifiers.

The Model 158-5460 eight-channel system (upper left photo) consists of an eight channel recorder assembly and eight Driver Amplifier-Power Supply units. To this basic assembly the user adds any combination of Sanborn "150" plug-in preamplifiers to meet his requirements. Each channel provides a 4 cm deflection.

The six-channel system (156-5460) has the same basic assembly, except for *two less* galvanometers and *one less* Driver Amplifier-Power Supply unit in each cabinet. Each channel provides a 5 cm deflection.

Both systems offer: *nine* chart speeds (0.25 to 100 mm/sec.); *extended* frequency response; *improved* regulated power supplies; *individual* stylus temperature control for each channel; *improved* control of input signals by 1, 2, 5, 10, 20, etc. attenuator ratios; controls for timing, manual and remote coding.

Also **8 and 6 Channel Systems for recording analog computer outputs,**



or other applications where 1 volt/cm sensitivity is usable. complete **eight-channel** system shown comprises four Model 150-2000 **Dual Channel** DC Amplifiers and an eight-channel Recorder Assembly. Each Dual-Channel Amplifier is complete with common power supply. (The six-channel version is identical, except for **two less** galvanometers and **one less** Dual-Channel Amplifier.) Also four channel models.

Write for catalog material on any Sanborn "150" Recording System

SANBORN COMPANY
CAMBRIDGE 39, MASS.

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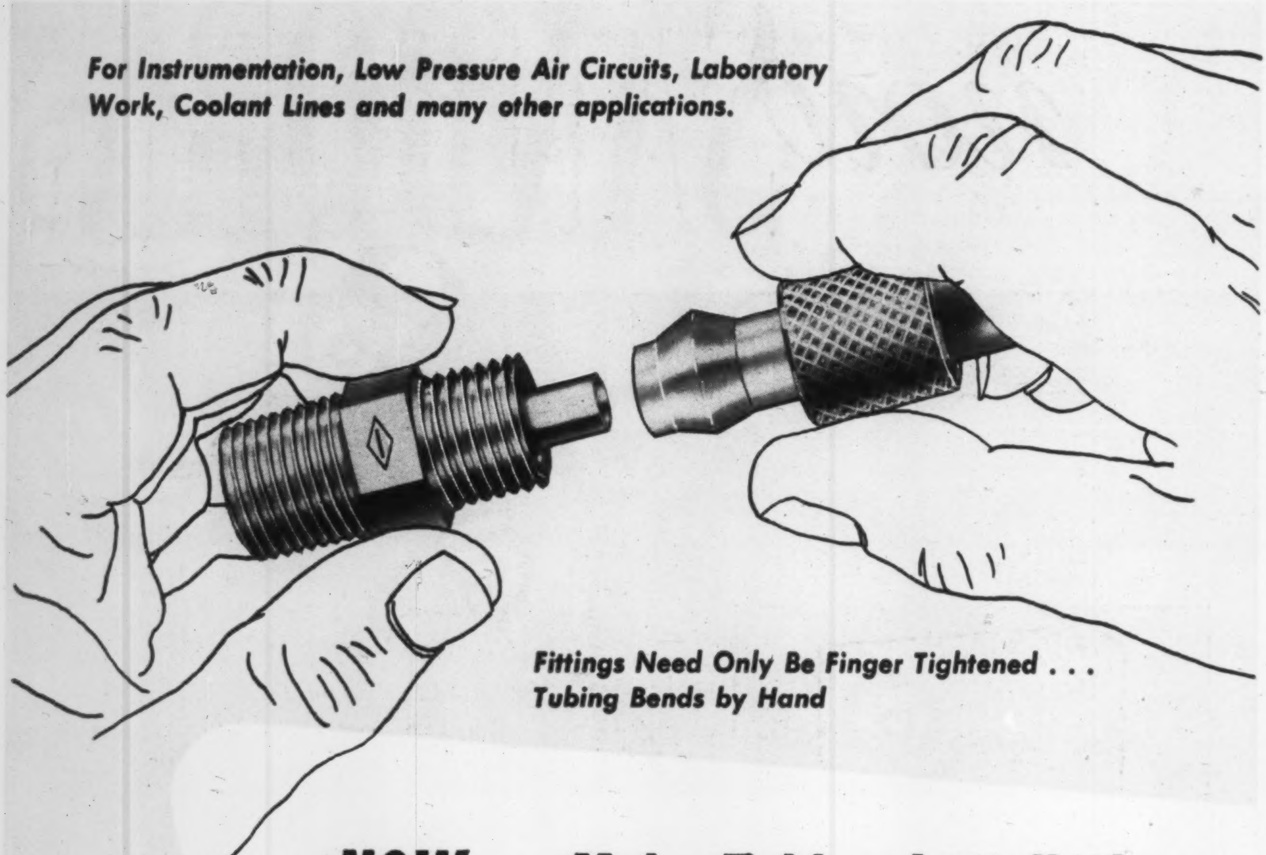

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Fittings Need Only Be Finger Tightened . . .
Tubing Bends by Hand

NOW . . . Make Tubing Installations at a FRACTION of Time and Cost the IMPERIAL Poly-Flo Way

IMPERIAL POLY-FLO TUBE FITTINGS, used with polyethylene tubing or other plastic tubing, *offer tremendous savings in time and labor* through ease of assembly and installation.

INSTALLATION IS AS EASY AS THIS! .... Simply cut tubing to desired length with knife or scissors. Bend tubing, which is very flexible, by hand to fit installation. Slip tubing and reversible sleeve over tube support. Nut need only be finger tightened. A wrench is never necessary.

IDEAL FOR MANY APPLICATIONS . . . instrumentation, laboratory equipment, chemical plants, food and beverage plants are but a few of the many uses. Tubing is very tough and impervious to most chemicals.

FITTINGS AND TUBING furnished in ¼", 5/16" and ⅜" O.D. sizes. Tubing supplied in 4 colors—color coding quickly identifies circuits. Recommended for working pressures to 125 psi.—¼" O.D.; 100 psi.—⅜" O.D. Temperatures from —90° F. to +175° F.

ACCESSORIES include tube racks for mounting of tubing; quick-disconnect and other shut-off valves; and convenient make-up kit of tubing and fittings.

THE IMPERIAL BRASS MFG. CO. 1204 W. Harrison St., Chicago 7, Ill.

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See Your
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He Carries Industry's Most Complete Line of Tube Fittings and Tubing Tools

1 He has big local stocks for quick delivery.
2 Helps you pick the right fitting and right tool for every job.

Ask for Bulletin No. 3025

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IMPERIAL

Industry's Most Complete Line of Tube Fittings and Tubing Tools

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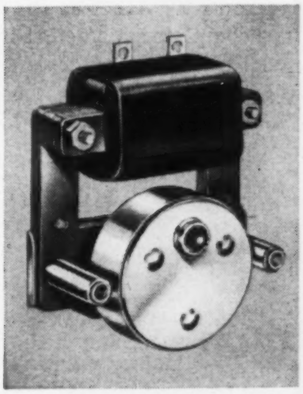
Where timing is important you'll find Telechron motors

Telechron motors are built for dependable, accurate timing!

In rubber manufacturing plants, for example, Telechron motors control the carefully calculated opening and closing of the mechanical goods press. Telechron motors also power the timers which control the mechanics of the curing cycle.

Telechron timing motors are equally essential to such widely varied industry as steel, milk, plastics (and a host of others, too). They are the choice of the instrument industry. Selected from experience as the most dependable made.

Write, wire or phone for our complete catalog and detailed information on our Application Engineering Service. Telechron Motors, General Electric Company, 64 Homer Avenue, Ashland, Mass.



EQUIPPED WITH Telechron MOTOR

Telechron®

MARK OF TIMING LEADERSHIP

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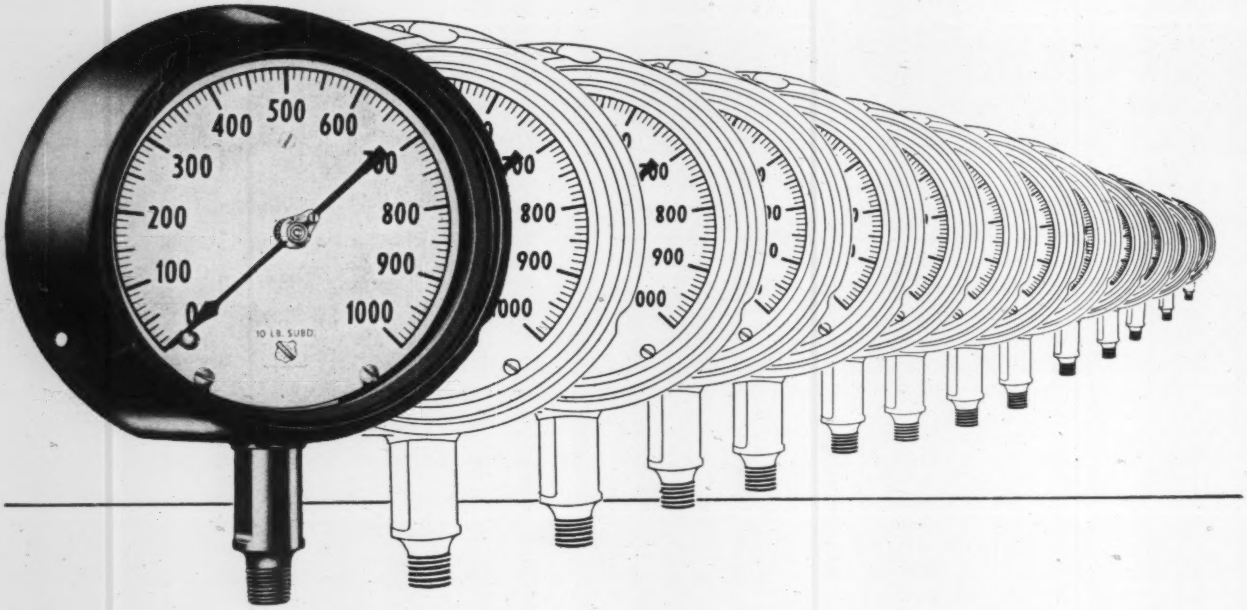
SATISFACTION MULTIPLIED
3 x 8 x 8 x 38 x 2 x 5



Service Conditions primarily determine the pressure gauge you specify for your installation. The wrong gauge can cost time, trouble, and money.

That's the big reason why Ashcroft Duragauges make sure of your complete satisfaction by offering a multiple choice in case designs and materials, Bourdon tube materials, ranges, movements, and dial sizes. Briefly, you can select the right gauge for your requirements from:

Cases of 3 different materials in 8 service-proved designs.

Bourdon Tubes of 8 different types of metals to meet specific service requirements.

Pressure Ranges from 30" vacuum or a few ounces through 100,000 psi.

Rotary Geared Movements that include the famous "Nylon Movement" or all stainless steel.

Dial Sizes from 4½" through 12".

Most important, Ashcroft Duragauges provide that unbeatable combination of highest sustained accuracy and durability of any pressure gauge built.

TAKE ADVANTAGE of the counsel of your nearby Industrial Supply Distributor. You can count on him to help you select Ashcroft Duragauges that will serve better and longer, with minimum maintenance, no matter how severe the conditions of vibration, pulsation, corrosion and weather.

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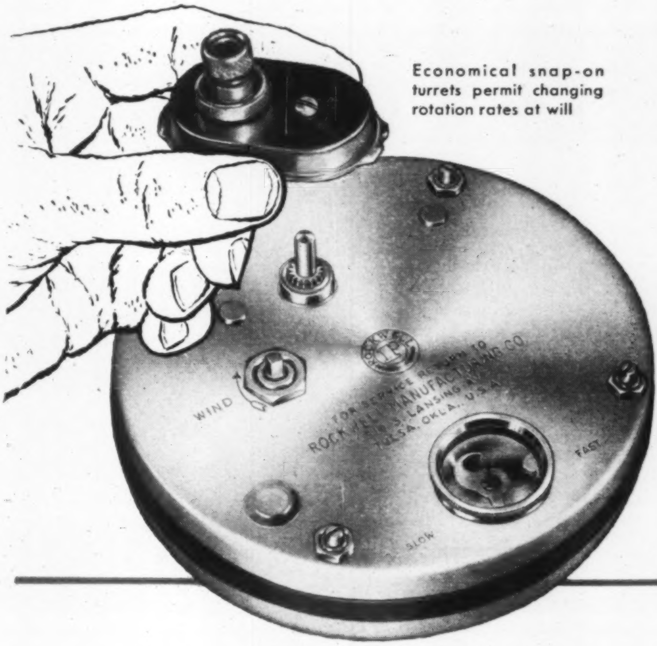

Economical snap-on turrets permit changing rotation rates at will

VERSATILE

is the word for...

ROCKWELL CHART DRIVES

with

Speed Changing Turrets

Fit Practically All Instruments . . . One Drive—Eleven Rotation Speeds

THE IDEAL REPLACEMENT DRIVE In designing the Rockwell Chart Drive, dimensions were deliberately established so that the drive can be adapted to fit practically all instruments. This is done by means of adaptors which are furnished for any standard make instrument. The adaptors correctly locate the drive both as to position and height.

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Such versatility in application makes the Rockwell the most economical chart drive you can use. Standardize on them for all your instruments. You'll save on inventory, in service and on reduced maintenance expense.

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Atlanta Boston Charlotte Chicago Dallas Houston Los Angeles
Midland, Texas N. Kansas City, Mo. New York Philadelphia
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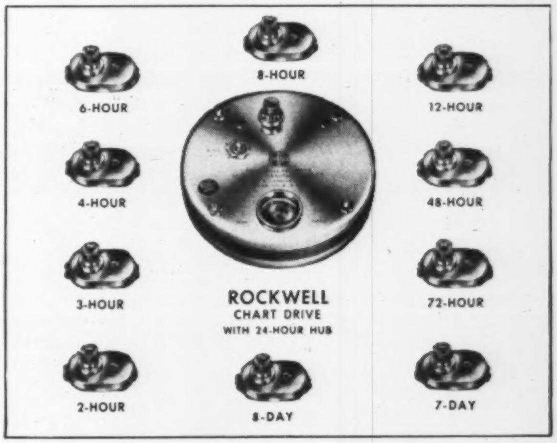
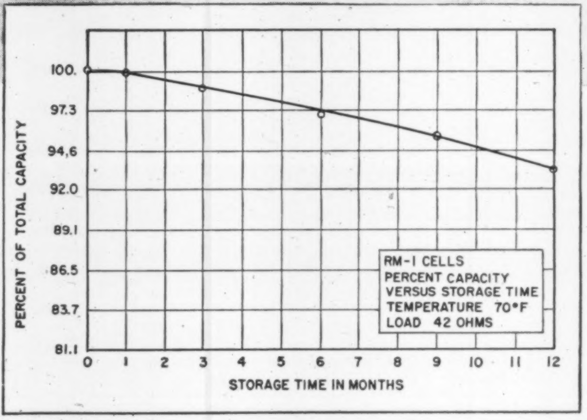
Here's How You Change Chart Rotation Without Removing Chart Drive From Instrument

No tools or special skills are needed to convert from one chart rotation speed to another. Just slip a turret of the rate desired onto the chart arbor and give it a quarter turn to lock in place. This exclusive feature eliminates the need for stocking assorted chart drives to meet varying requirements.



Rockwell Chart Drive and Turrets
For Eleven Rotation Speeds

For more information circle **30** on inquiry card.



For Long Shelf Life... Use Mallory Mercury Batteries

For battery-powered instruments that operate intermittently . . . or for applications involving long periods of idleness, the long shelf life of Mallory Mercury Batteries is an important characteristic.

Mallory Batteries do not deteriorate or lose an appreciable amount of power during long storage periods, even under the most adverse conditions of humidity and temperature extremes. The curve shown is typical of the performance you can expect when Mercury Batteries are used for instrument power supply.

For continuous or intermittent operation at microampere drains or loads of 50 amperes, Mallory Mercury Batteries have many important advantages that will help you design lighter, more compact equipment . . . equipment that will give more hours of service life.

Let us send you a copy of our new Technical Bulletin 1-6. It contains complete information on single cells and multi-cell stacks and packs.

Here are other advantages that may suggest ways you can use Mallory Mercury Batteries to advantage

- High ratio of energy to volume and weight
- Leak-proof, dimensionally stable construction
- Uniform discharge characteristics
- No need for recuperation periods
- Operation over wide temperature and pressure ranges
- Resistance to humidity and corrosive conditions
- Highly resistant to impact and acceleration

For Transistor Applications

The constant voltage-constant current characteristics of Mallory Mercury Batteries make them exceptionally well suited to transistor applications.

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SERVING INDUSTRY WITH THESE PRODUCTS:

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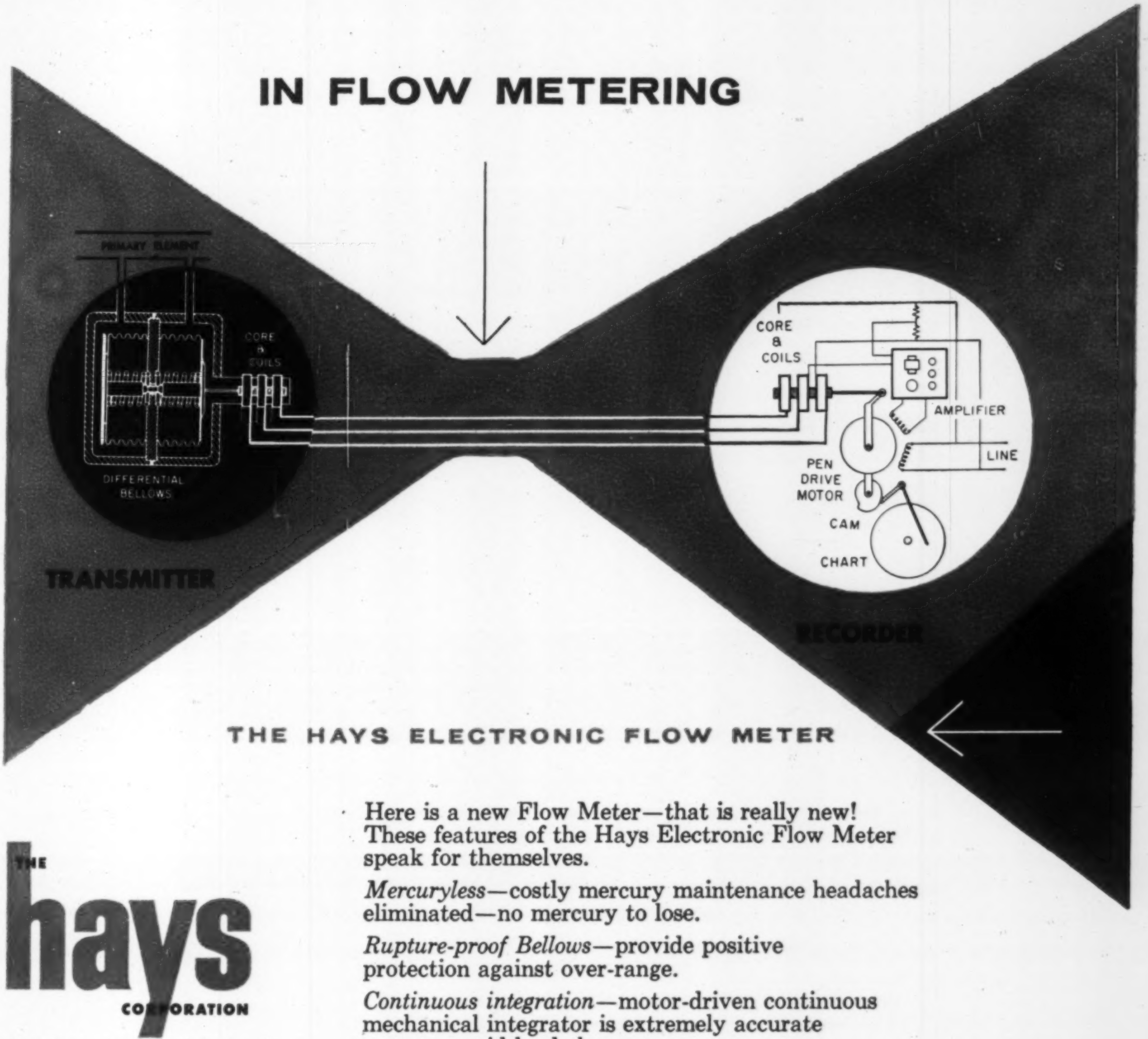
new dimensions

IN FLOW METERING



THE HAYS ELECTRONIC FLOW METER

Here is a new Flow Meter—that is really new! These features of the Hays Electronic Flow Meter speak for themselves.

Mercuryless—costly mercury maintenance headaches eliminated—no mercury to lose.

Rupture-proof Bellows—provide positive protection against over-range.

Continuous integration—motor-driven continuous mechanical integrator is extremely accurate even on rapid load changes.

Electronic operation—requires only 4 seconds for full scale pen travel with accuracy of ¼% of full scale differential.

Other features include null-balance transmission, powerful motor, easy readability, accuracy unaffected by normal temperature changes. Explosion proof transmitters and wide range meters also available.

For complete information, write for Bulletin 54-1074-222.

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MICHIGAN CITY 8, INDIANA

Automatic Combustion Control • Veriflow Meters and Veritrol • Electronic Oxygen Recorders • CO₂ Recorders Boiler Panels • Gas Analyzers • Combustion Test Sets Draft Gages • Electronic Flowmeters • Miniature Remote Indicators • Electronic Feed Water Controls

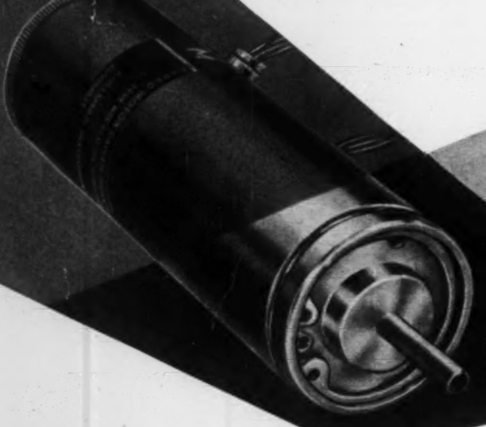
For more information circle **32** on inquiry card.

COMMON CHARACTERISTICS OF ALL TYPE 2131 GEARED MOTOR GENERATOR UNITS

O.D. of Case............1.000 inch
Case Length............3.301
Weight............7.5 ounces
Frequency............400 cycles

No. of Poles (Motor)............6
*No Load Speed (Min.)............6500 rpm
Rotor Inertia............1.1 gram-cm²

*Motor Speed at input to gear train



NEW integral gear head in small servo motors

OUTSTANDING FEATURES OF TYPE 2131 GEARED MOTOR GENERATOR

- New methods of manufacture result in high efficiency
- High torque to inertia ratio to give fast response
- Available for 115 volt—115 volt two phase or single ended tube operation
- High impedance winding for direct plate to plate operation available
- High generator output voltage with excellent signal to noise ratio
- Zero degree phase shift in generator
- All metal parts corrosion resistant
- Extremely wide operating temperature range

Other models of one inch O.D. units

TYPE NO.	DESCRIPTION
2103	Induction Motor
2101	Geared Induction Motor
2028	Motor Generator

A new line of units has been added to the Kollsman "Special Purpose Motors" family combining precision machining, advanced electrical design and the latest in new materials. An unusual feature of the new line is the integral gear head unit. Contained within a single case is the gear train and motor; or gear train, motor and generator. Gear ratios as high as 300:1 can be supplied.

This new line consists of Induction Motors and Induction Generators supplied separately or combined in a single case one-inch in diameter. The new motors have been designed to give the maximum torque per watt ratio with the minimum rotor inertia. The generators have been designed to give the maximum output voltage with the minimum residual voltage and phase shift.

One of the principal features of the Kollsman "Special Purpose Motors" is the interchangeability of parts which permits numerous electrically different combinations of motor and generator windings within the same case.

INPUT PER PHASE ONLY 1.8 WATTS

ELECTRICAL CHARACTERISTICS
OF TYPICAL TYPE 2131 GEARED MOTOR GENERATORS

	MOTOR					GENERATOR		
TYPE NO.	EXCITATION FIXED	EXCITATION CONTROL	INPUT PER PHASE	STALL TORQUE	Theoretical Acceleration At Stall	EXCI-TATION FIXED	INPUT	OUTPUT PER 1000 rpm
2131-0411110	26	26	2.3	0.4	25600	26	1.8	.51
2131D-0412120	26	26	4.0	0.6	38500	26	2.2	.68
2131D-0413120	26	26	1.8	0.3	19200	26	2.2	.68
2131-0460600	115	115	4.0	0.6	38500	115	2.6	1.00
2131-0463600	115	55	4.0	0.6	38500	115	2.6	1.00
2131-0470600	115	P-P	4.0	0.6	38500	115	2.6	1.00
	volts	volts	watts	Oz-n	rad/sec²	volts	watts	volts

Latest catalog and/or complete specification drawings will be sent upon request.

kollsman INSTRUMENT CORPORATION

80-22 45th AVE., ELMHURST, NEW YORK • GLENDALE, CALIFORNIA • SUBSIDIARY OF *Standard* COIL PRODUCTS CO. INC.

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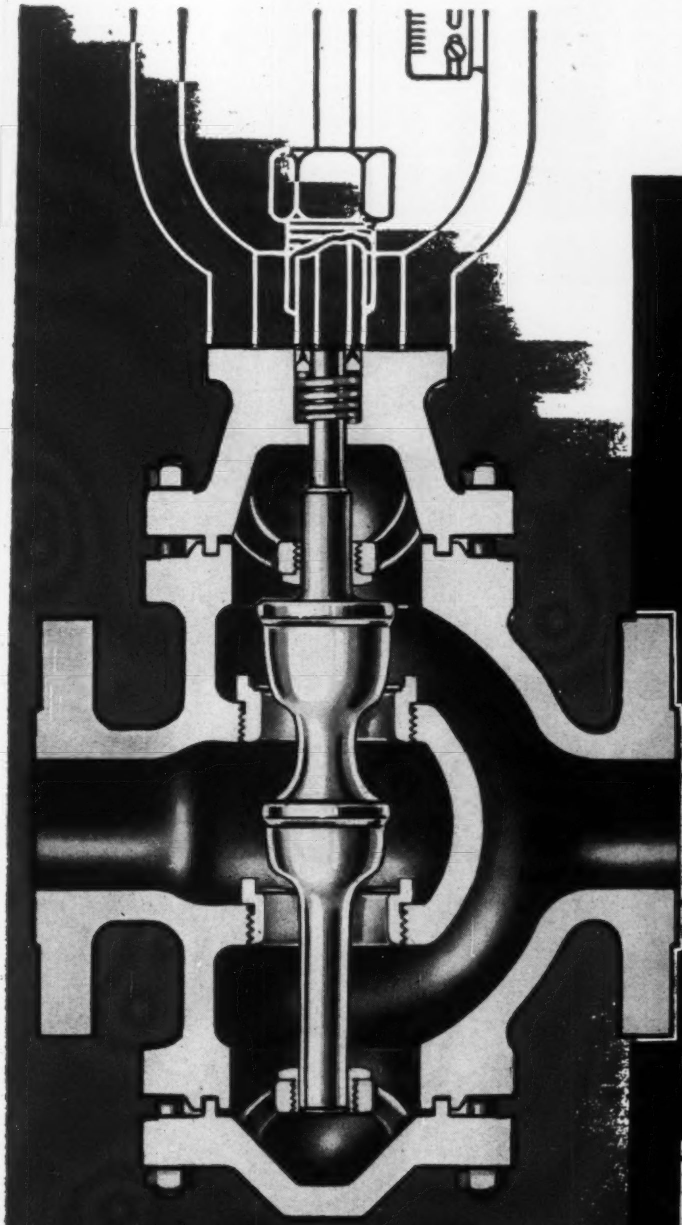

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IS THE VALVE MANUFACTURER THAT LAPS THE SEATS OF DOUBLE PORTED VALVE BODIES AT OPERATING TEMPERATURES

Fisher valve being steam heated to specified operating temperature.

Inner valve being "ground in" while assembly is hot.

Insures superior control with tighter shut-off on high temperature service. Both upper and lower seating surfaces contact simultaneously at specified operating temperatures.

FISHER

Our 75th ANNIVERSARY

FISHER GOVERNOR COMPANY • MARSHALLTOWN, IOWA

WORLD LEADER IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

For more information circle **34** on inquiry card.

chicago, navy pier
1955

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Analog-to-digital converters
Analytical control equipment
Automatic control valves
Automatic control systems
Automatic feeding devices
Automatic gaging equipment
Automatic handling equipment
Automatic inspection devices
Automatic loaders
Automatic machine controls
Automatic tape controls

Beta-ray thickness gages
Brakes, clutches and
  drive mechanisms

Central control systems
Color process controls
Communication systems including
  closed circuit television,
  telephone and paging systems
Compressors for automation air
Computers, analog or digital
Computer components
Continuous gas analyzers
Continuous testers

Conveyors
Counters

Data processing and
  data reduction systems
Data transmission and
  computing systems
Decade counters
Door operators, automatic
Dust and atmosphere controls

Electric motors
Electronic computers
Electronic control devices
Electronic, electrical and
  mechanical components for
  automatic production systems

Gages, air
Governors

Hydraulic cylinders and motors

Indexing machines
Industrial television, closed circuit
Infrared absorption analyzers

Instrumentation and automation
  panels and cubicles
Instruments for measurement
  and control

Level controllers
Limit switches

Mass spectrometers
Metering equipment
Monitoring systems
Monorails
Motor controls

Optical gages and
  inspection devices

Packaged servo controls
Photoelectric control devices
Pneumatic tubes
Positioning equipment
Power supplies
Printed code readers

Radioactivity equipment
Recording equipment

Remote control systems

Scales
Scanning systems
Servo-components
Servomechanisms
Signalling equipment
Speed controls
Strain measuring devices for
  automatic control
Switches, relays and other
  electrical components

Teleprinters and facsimile
  recorders
Two-way radio

Ultraviolet absorption analyzers

Vibration control equipment

Weighing and proportioning
  equipment
Work positioning mechanisms

X-ray and flouroscopic devices
X-ray gages

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For more information circle **35** on inquiry card.

the second
international

AUTOMATION

exposition

For what promises to be the most important event in

AUTOMATIC CONTROL
AUTOMATION
INSTRUMENTATION

ever held, the Second International Automation Exposition has reserved the facilities of Chicago's famed Navy Pier.

All technical sessions and clinics—including the important electronic computer clinic—will be held in the Pier's meeting rooms. Restaurant and lounging facilities, so necessary for a successful show, will be arranged in the exhibit halls.

With its ideal geographical location, Chicago will attract thousands of engineers and scientists from all over the world. For the exhibitor, the 1955 Automation Exposition will open new channels to the successful application of Automation.

chicago, nov. 14-17

International Automation Exposition, 845 Ridge Avenue, Pittsburgh 12, Pennsylvania

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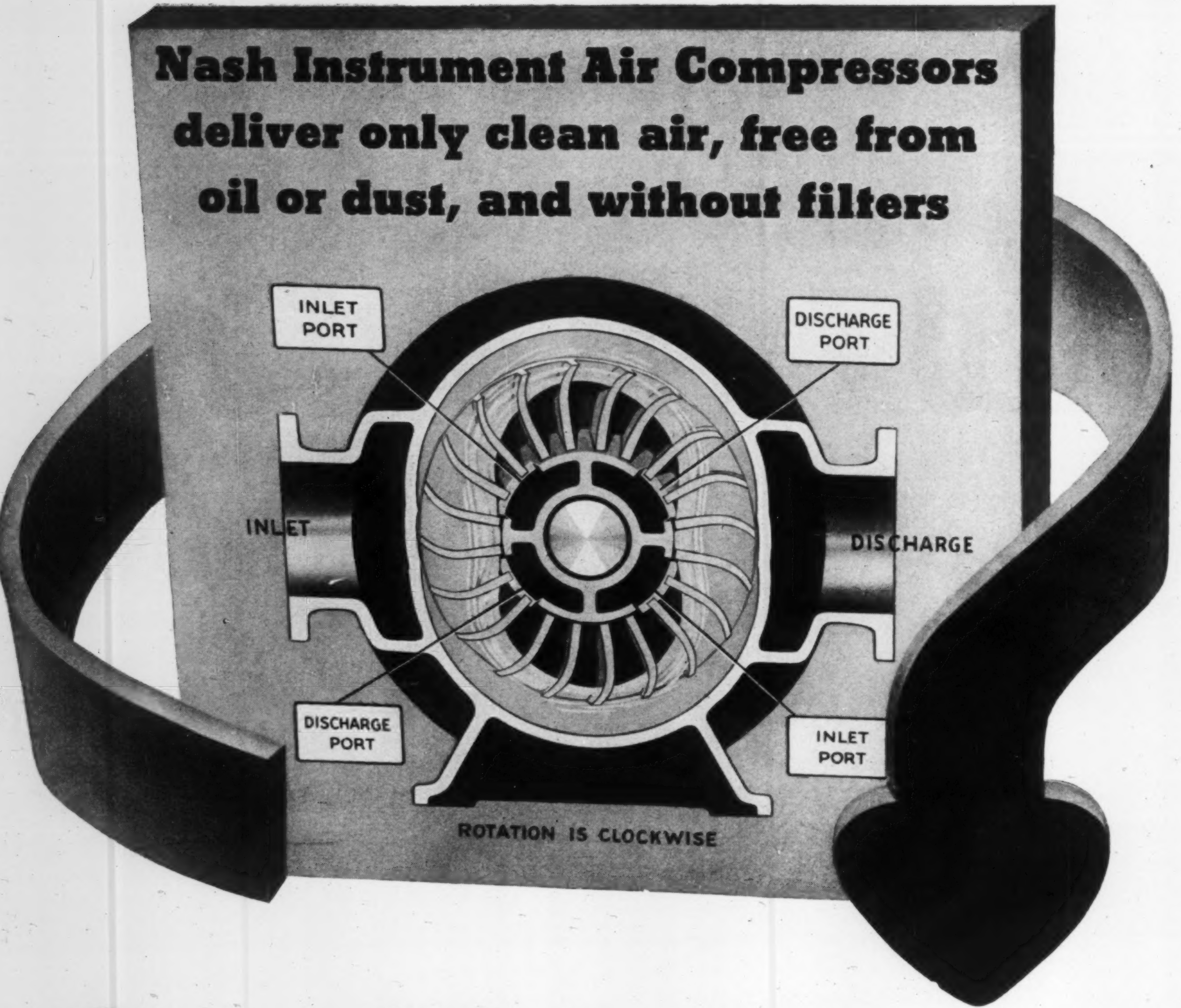
Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters
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ROTATION IS CLOCKWISE

Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

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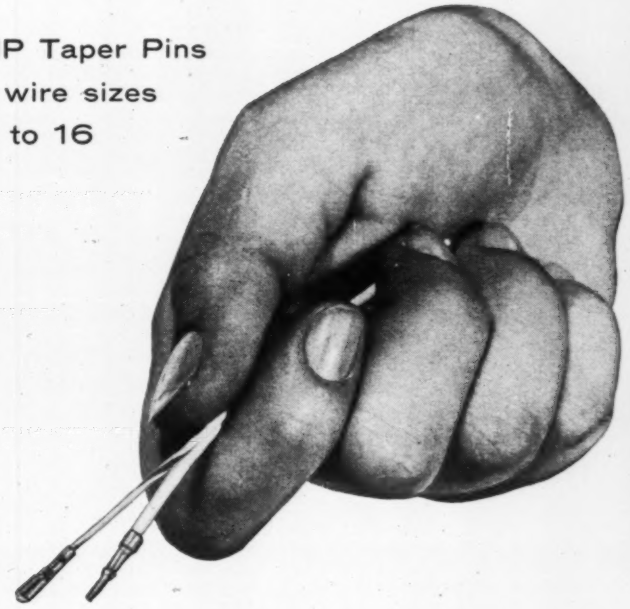
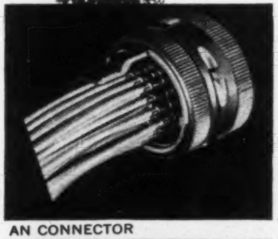
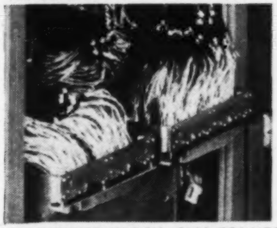
AMP Taper Tab
receptacles for wire
sizes 26 to 18

AMP Taper Pins
for wire sizes
26 to 16

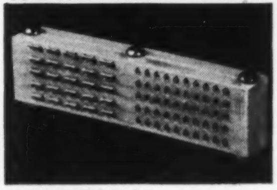




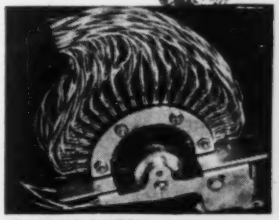
AN CONNECTOR



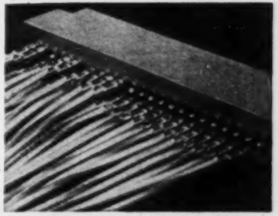
CONNECTOR BLOCK—2000 CONNECTIONS



A-MP TAPER BLOK



STEPPING SWITCH



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WITH ADDED RELIABILITY

Cubic restrictions have brought about a whole new concept of wire termination. The AMP Taper Technique with AMP taper pins, tab receptacles, blocks and modified miniature components will help you take full advantage of small wire, small insulation and small space for your wire terminations.

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For more information circle **36** on inquiry card.

are you fighting space?

connect with cannon!

Are you looking for complete electrical circuit dependability in a very, very small space?

If so, you should use Cannon carefully engineered miniature and sub-miniature multi-contact connectors. In ½ or ⅓ the usual space, they give you up to 50 contacts, the same number as a standard connector, and still retain **all** the factors of utility, reliability, and mechanical strength found in Cannon's standard size connectors. They are very rugged, easy mating, unusually versatile, neat and compact.

Miniatures—Maximum Dimensions Only 1" x 2"!

MINIATURE
SUB-MINIATURE
SUB-MINIATURE
MINIATURE

High-dielectric insulation. Rack, panel, chassis types . . . receptacles and plugs, standard, pressurized, or hermetically sealed . . . box, wall, or cord mountings . . . for audio, control, and instrument use. D and U sub-miniatures have steel shells. DPA and K miniatures have die-cast shells. Five-ampere gold plated contacts are found in all miniatures and sub-miniatures, excepting U receptacles, which have steel contacts. Larger contacts having higher current ratings, and co-ax contacts, are in process of development.

Sub-Miniatures—Only 2-5/8" x 39/64"!

first in connectors

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Editorial...

INSTRUMENTS and AUTOMATION

Computers

Everyone is aware of the tremendous publicity that has been given the field of computers—but few are aware of the fact that most of this publicity has been superficial, out of perspective, and of little practical value either to computer users or customer prospects. Specifically, little has been published that has been either basic enough to teach the average industrial engineer anything about the principles and operation of computers, or practical enough to inform the computer owner about the specific problems of operating a computer.

A primary source of excellent operational data has been available in *The Simulation Council Newsletter*, a monthly report edited by John H. McLeod, Jr., and subscribed to by many owners and users of computers, as well as members of the several Simulation Councils. (So far the Western, Midwestern and Eastern. There is talk of others.) Mr. McLeod has done a remarkable feat in interpreting the monthly meetings of the Simulation Councils, comprising men who make and operate computers, and who meet to discuss their operational problems. Needless to say the Council meetings are full of practical, meaty, fundamental data—which Mr. McLeod interprets with high technical skill and delightful literary style.

We take great pride in announcing that Mr. McLeod, who is introduced to you on the next page, is joining our staff as Editor of *The Simulation Council Newsletter*, which will appear monthly as a special feature in *Instruments and Automation*.

The first issue of *The Simulation Council Newsletter* was issued in November, 1952. The value of this service is indicated by the fact that, despite an annual charge of $10 for the report, subscriptions rose from 35 to almost 200, with readers throughout the U. S. and also in France, England, Germany and Canada.

MR. McLeod originated the *Newsletter* shortly after he organized the original Simulation Council in Southern California, consisting of governmental agencies, contractors, aircraft companies, and educational institutions engaged in use of simulation technique. (Mr. McLeod defines simulation as the use of analog computers, or electronic differential analyzers, and associated equipment to simulate the performance of complex systems.) The *Newsletter* now incorporates the minutes from all Simulation Council meetings, of which there are three—Western, Midwestern, and Eastern. It also reports the meetings of the Industrial Analysis and Control Council, and those meetings of the Association for Computing Machinery and other organizations in the field which the McLeods are able to cover. The valuable news from these organizations—all on the frontiers of computing—will thus be available to a wide audience of industrial and scientific complexion when incorporated in I & A. This has deep significance for all industry because the true potential of computers is revealed dramatically in the discussions of those who own and operate them.

This coverage will do much to solve the second of the situations referred to previously—the lack of basic operational data about specific problems.

THE first of the situations—lack of fundamental educational data—is being attacked by bringing you a complete series of articles based on the First Computer Clinic held in conjunction with the First International Automation Exposition in 1954.

You may be interested in the background of this I & A series of articles, which we believe to be the most powerful material ever assembled in this field. Your editor was director of this Clinic. We submitted tentative outlines to each of the computer manufacturers, and told them that they would lecture for two hours to about 200 men (in classes of 20 to 30), of widely different backgrounds—some would be "computer men," others "instrument men," still others would be bankers and financiers.

The computer principals were skeptical; some said it couldn't be done. Your editor told them that if, in two hours, they couldn't get across how their equipment operates and what it would do, then their future was not nearly as rosy as many have been prophesying. Points of emphasis were given to each computer lecturer, in order to avoid excessive duplication. The computer manufacturers went to work—and did the job. The results are more than gratifying; they are of startling value. This is what was needed—and here it is, beginning in this issue.

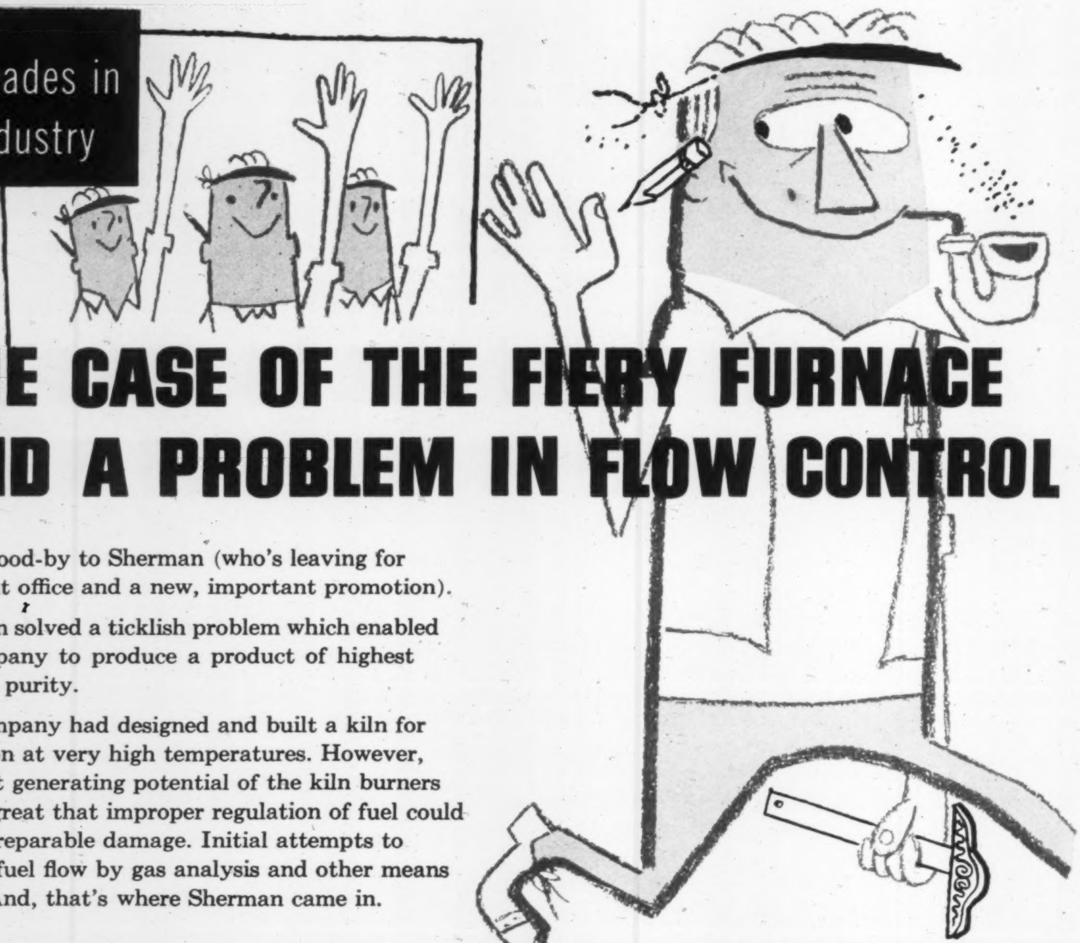
We wish also to direct your attention to the difference between this I & A approach to the field of computers in industry and the "conventional" approach. The latter either talks about mythical computer-controlled manless factories (figments of immature minds, which have done harm to the field) or about design data such as "how to reduce pot loading errors." As you will find from the I & A series on computers, when operating a computer you eliminate these pot loading errors simply by setting the attenuators while watching a precision voltmeter. That is all; *the computer user does not need to worry about designing a computer.* This is typical of the practical material in this important series on computers.

TO prepare for this complete and unique coverage of the field of computers, we have been feeding you bits of "Trend" data, month by month. We repeat them here:

> **"Analog computers will find extensive application in industrial operations when industrial engineers learn the new techniques for simulating process operations. Techniques do not require advanced mathematics (April, 1954, page 523)**
>
> **"Watch for rebirth of the differential equation (now quickly forgotten by engineers other than theoretical design engineers). The analog computer is giving new**

←Circle 37 on inquiry card.

S/K apades in industry



THE CASE OF THE FIERY FURNACE AND A PROBLEM IN FLOW CONTROL

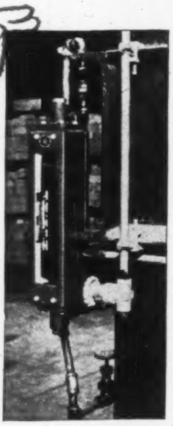
Wave good-by to Sherman (who's leaving for the front office and a new, important promotion).

Sherman solved a ticklish problem which enabled his company to produce a product of highest possible purity.

The company had designed and built a kiln for operation at very high temperatures. However, the heat generating potential of the kiln burners was so great that improper regulation of fuel could cause irreparable damage. Initial attempts to control fuel flow by gas analysis and other means failed. And, that's where Sherman came in.

Sherman remembered reading an article which offered a condensed bulletin on all types of SK Rotameters—accurate, variable area instruments for measuring and controlling fluid rate of flow.

He sent to SK for a copy of Bulletin 18-RA, checked the types of meters described, found a Rotameter to be ideal for the purpose, and called in a specialist—his nearest SK Sales Engineer.



SOLVED THE PROBLEM NEATLY!

An SK Safeguard Rotameter is used to measure the flow of fuel oil to the burners. In operation for some time, the Rotameter has protected the equipment against damage, saved the operator time, and even helped save some fuel by providing simple and accurate rate of flow measurement.

MORAL! *Request a copy of Bulletin 18-RA for your files. Make use of a qualified specialist, your nearest SK Sales Engineer.*

Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS
2225 STATE ROAD, CORNWELLS HEIGHTS, BUCKS COUNTY, PA.

Jet Apparatus • Heat Transfer Equipment
Strainers • Condensers and Vacuum Pumps
Oil Burning Equipment • Rotameters
Flow Indicators • Radiafin Tubes • Valves
Spray Nozzles and Atomizers • Gear Pumps
Desuperheaters

For more information circle **38** on inquiry card.

EDITORIAL—CONTINUED

meaning to the differential equation, making it possible to solve operation problems via simulation, and making it necessary for all engineers to brush up on math." (July, 1954, page 995)

"Watch for dramatic news about new uses for computers in process industries. First computer clinic offers opportunity for Instrument and Process Engineers to learn new techniques." (August, 1954, page 1127)

"Use of computers is only new thing in 'new' field of automation, says recent Harvard report. First computer clinic offers opportunity to see various types in demonstrations." (September, 1954, page 1359)

"The Instrument Department of the modern plant has the responsibility and know-how for operation of complex controllers . . . it could make most effective use of the analog computer. Then why doesn't it? The impasse is this: It is the limited knowledge of process functions that holds back application of the computer . . . and it is limited knowledge of simulation technique (on the part of the Instrument Department) that limits the knowledge of the process functions. The Instrument Department holds the key to this viscious-circle situation." (October, 1954, page 1550)

"Men in charge of the instruments, controllers, and computers will become the key men in automated operations. Instrument departments which started as small repair facilities with less than ten men have, in a few years, grown to central control centers with high-caliber personnel in the hundreds. Computers could put instrument department in charge of all plant operations, could make instrument department the systems manager." (October, 1954, page 1683)

"Single modern development with greatest potential is the electronic computer. Data processing computers are now changing functions of larger offices throughout U. S.; digital and analog computers are now changing methods of all design engineers. Analog computer could put working model of unit chemical processes (and complete plants) in hands of the plant operating center —the instrument department." (October, 1954, page 1683)

"First Computer Clinic (New York, Nov. 30-Dec. 2) is unique opportunity for engineers, instrument departments, and operating personnel to get working demonstrations and perspective on entire field of computers—for first time. Clinic sessions will be offered by Austin (special purpose computers), Bendix (digital computers), Electronic Associates (analog computers), Goodyear Aviation (analog computers), International Business Machines (data processors and digital computers), Remington Rand (data processors and digital computers). Note complete coverage of all basic types. Attendance has registered from all parts of U. S. for this important Clinic." (October, 1954, page 1683)

"Analog computer purchases (gross) are expected to be $8-10 million for 1954; $15-20 million for 1955. Over $40 million worth of analog computers are in current use; industrial market is expected to 'break' soon with great increases at operational level." (December, 1954, page 1877)

"Commercial electronics (office computers) will expand from present 8% to 25% of computer sales, and will become a $10 billion market in next 10 years, says W. J. Morlock of General Electric Commercial Equipment Dept." (January, 1955, page 9)

"First Computer Clinic at New York Automation Exposition attracted 200 registrants from 24 industries and 26 states (plus Canada and England). Process men saw control problems solved by use of only transfer functions (no tough equations); factory men saw machine-tool problems solved by computers; business men saw various functions of data processors; all saw primary and intermediate fields of application for all types of computers." (January, 1955, page 9)

"Each new advance in computers opens new avenues of attack on previously unsolvable problems." (February, 1955, page 173)

"Computers are giving new perspective to mathematics. Industrial engineers will find it necessary to develop transfer function descriptions of all industrial unit operations for proper analysis of systems to assure optimum operation." (February, 1955, page 173)

Meet the McLeods

John H. McLeod, Jr., Head of the Functional Simulation Branch, Guidance Div., Naval Air Missile Test Center, Point Mugu, Calif., has been publishing the now well-known *Simulation Council Newsletter* since November, 1952. This was shortly after he sparked the formation of the first Simulation Council. The primary purpose of the *Newsletter* is to report the Council discussions.

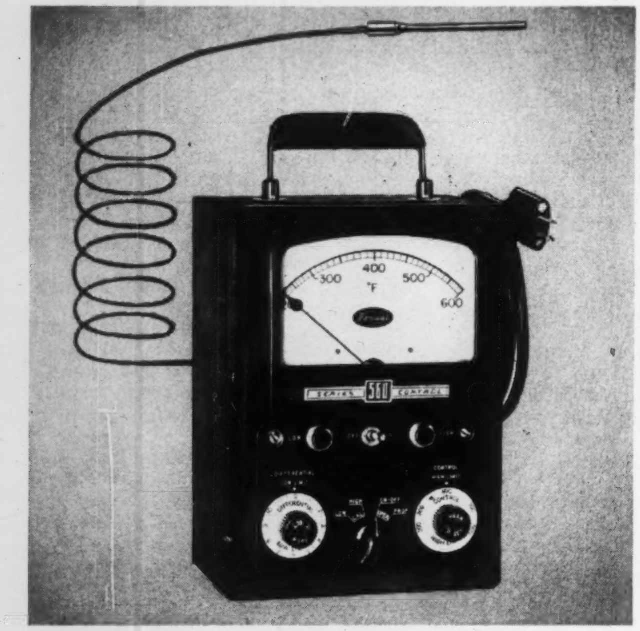
The high value of the *Newsletter* stems from the fact that simulation technique opens a new frontier for industrial, as well as military and engineering, instrumentation. And the technique is most apparent from the discussions of those engaged in simulation. It is in recognition of this fact that *Instruments and Automation* will, beginning with this issue, publish monthly the *Simulation Council Newsletter*. This will make the *Newsletter* available not only to all present subscribers to the *Newsletter* but also to all subscribers to *Instruments and Automation*. The *Newsletter* now reports the discussion of the Western, Midwestern, and Eastern Councils, plus those of the Industrial Analysis and Control Council; meetings of the Association for Computing Machinery, the IRE, PGEC, and others concerned with computers and simulation are also covered when possible.

The *Newsletter* and Bob Lowry, former Secretary of the Midwestern S. C., were instrumental in the forming of the Midwestern and Eastern Councils, which are now headed by Dr. Milton Warshawsky of WADC and Dr. Harold Skranstad of the National Bureau of Standards, respectively.

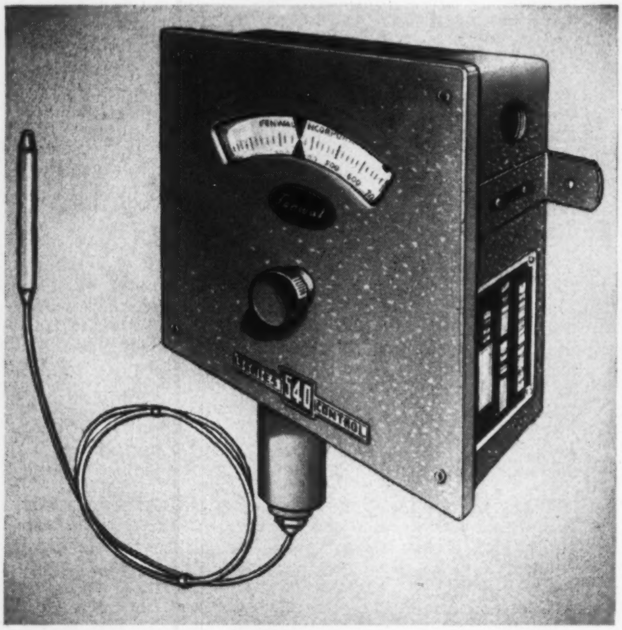
John McLeod, your editor of The Simulation Council Newsletter, and Suzette (McLeod)—whose inspiration and work made it possible.

McLeod was born in Hattiesburg, Mississippi, February 27, 1911. He graduated from Tulane University in 1933,

Which of these two instruments provides the temperature control accuracy you need?

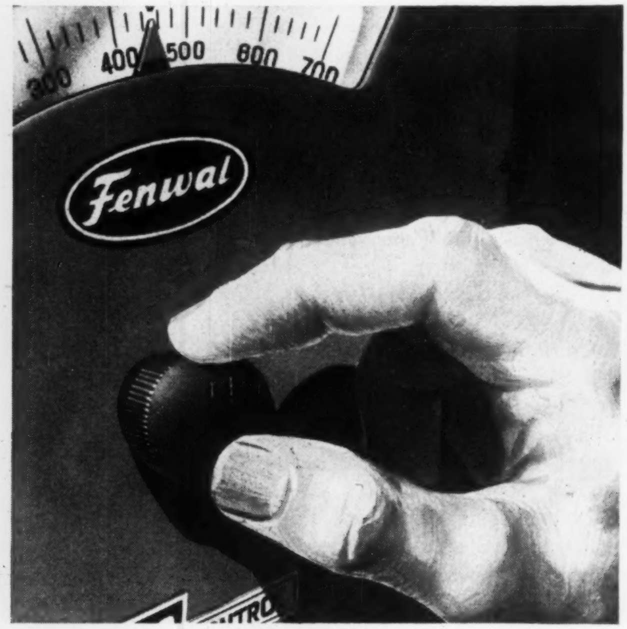


1. IT'S ELECTRONIC! The new Series 560 applies the thermistor principle in temperature indicator controls with heretofore unattainable accuracy over a scale range of 200° to 600°F. It's the *only* instrument that provides the three major control modes — (1) on-off (2) proportional (3) adjustable differential — all at the flip of a switch. Wide range of use for general laboratory, processing, molding or packaging applications.



2. IT'S MECHANICAL! The new Series 540 indicating controller combines low cost with high accuracy over a temperature range of 100° to 700°F. Temperature changes are transmitted by a bulb and bellows to an indicator control. Instrument features on-off control . . . adjustable differential . . . ambient compensation. May be flush or surface mounted. Capacity of 15 amps at 115 volts.

3. SIMPLICITY ITSELF is secret of Fenwal's Series 560 — accuracy, sensitivity and ruggedness. The thermistor's high resistance change permits operation with any length of lead wire up to 200 feet without affecting signal strength or accuracy. Thermistor is hermetically sealed in glass for stability; encased in stainless steel for ruggedness. No complex circuitry; maintenance is easy.



4. EASY "SET" AND "CHECK" OPERATION is a feature of Fenwal's Series 540 which is accurate to within 2% over the 100° to 700°F range, including the effects of ambient temperatures. Send for FREE NEW BULLETINS, MC122 on the Series 540, MC123 on the Series 560. Both contain full data you should have. Write to **Fenwal Incorporated, 364 Pleasant St., Ashland, Mass.**

Fenwal Controls Temperature. . . *Precisely*

For more information circle **39** on inquiry card.

with a degree in mechanical and electrical engineering. His experience includes the application of Automatic Control Instruments as Field Engineer with Taylor Instrument Companies, and their design as Research and Development Engineer with Leeds & Northrup Company. Since 1947 he has been concerned with the automatic stabilization and control of guided missiles, and the analysis and synthesis of control systems by means of analog computer techniques at the USNAMTC, Point Mugu.

He has presented papers at two Cyclone Symposia, the Typhoon Symposium, the 1954 National Association of Computing Machinery Convention, the American Rocket Society's 1954 Fall Meeting, and the recent Louisiana State University High-Speed Computer Conference.

Your editors believe that you will enjoy Mr. McLeod's literary style, as well as benefit from the great insight that his reports give to the new technique of simulation.

McLeod tells us "the most appropriate picture to use with any mention of me is that of Suzette and me, because it was Suzette who suggested the *Newsletter* and whose hard work made it possible." Thus we invite you to meet both John and Suzette.

Note that Mr. McLeod first worked in industrial instrumentation—and from there entered the "then-new" field of analog computation, where he discovered completely new and different techniques and procedures for instrumentation. In the brief time from 1952 to 1955 the new techniques were perfected and standardized, commercial equipments became available, basic circuits were developed for hysteresis and other nonlinearities, the great potentials of simulation for industry became apparent, and the new techniques became ready for the industrial field. The appearance of the *Simulation Council Newsletter* in *Instruments and Automation* thus marks the beginning of a new era, the introduction of simulation techniques into the industrial instrument field. Mr. McLeod has returned from whence he started; the tide of events has turned full-circle.

Clearing House for Meetings

With the growth of interest in instrumentation and automation has come vastly increased numbers of technical meetings—local, national, and international. Many of these are arranged years in advance—and many persons find it essential to attend the meetings of primary value in their field. Needless to say, conflicts in scheduling are arising frequently—for example, the 10th Annual Instrument Exhibit and Conference of the Instrument Society of American (California) and the Production Engineering Show (Chicago) both occur in the period of September 12-16, 1955. Men who should attend both must choose one or the other.

To clarify this situation, the Instruments Publishing Company, oldest of the publishers in the field of instrumentation and most familiar with the many meetings directly related to this field, is starting a new service—a clearing house for instrumentation and automation meetings. All societies and organizations in the field are being informed that this clearing house is available; all meetings related to the field will be calendared for a period of five years in advance.

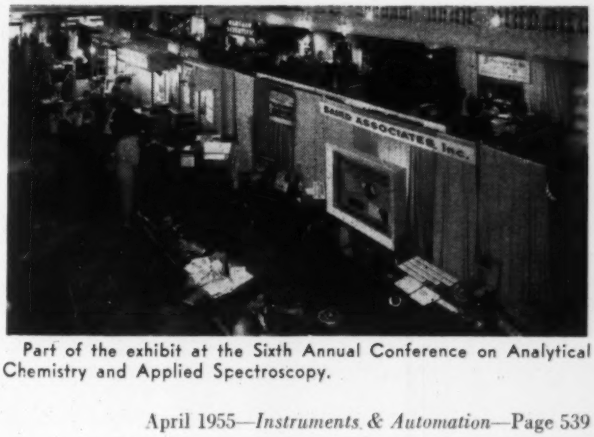
All organizations which plan to hold meetings or exhibits on instruments, automation, computing, analysis, testing, inspection, gaging, automatic control, and allied subjects will find it to their advantage to check with this master calendar before scheduling a meeting or conference—and then notify the clearing house when the meeting is scheduled. This service is being offered free of charge to all technical societies in the United States and overseas.

Regional Conferences and Exhibits Grow

Two regional conferences held in Pittsburgh, Pa. (Analytical and Iron & Steel) show the increasing importance of the segmental approach to the field of instrumentation. The *Sixth Annual Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy* was held Feb. 28-March 4, 1955, at the William Penn Hotel, sponsored by Pittsburgh Section, ACS, and the Spectroscopy Society of Pittsburgh. More than 2000 men from all parts of the United States and Canada registered to hear the 122 short papers and see the 57 exhibit booths of the 37 exhibitors.

Of particular news interest in the exhibit were the new nuclear-magnetic-resonance spectroscopes of Varian Associates, the Phillips Petroleum industrial line that is now being marketed by Consolidated Engineering, and the Beckman electronic colorimeter. The Varian nmr equipment lends itself to analysis of atomic structure, particularly for the oil and organic industries, and fills the gap left by the mass-spectrometer requirement for gaseous samples because it uses solid samples. The rugged Phillips automatic differential refractometer offers a simple approach to many analytical processing problems.

The technical sessions covered the fields of colorimetry, organic, metals and alloys, mass spectra, near-infrared spectroscopy, high-resolution spectroscopy, X-ray fluorescence analysis, the KBr pellet technique, Raman spectroscopy, and others. C. M. Marstiller, R. K. Scott, and R. G. Russell are to be congratulated for the excellent management of this conference that grows in importance annually.



Part of the exhibit at the Sixth Annual Conference on Analytical Chemistry and Applied Spectroscopy.

Iron & Steel Instrumentation

The Fifth Annual Conference and Exhibit on Instrumentation in the Iron & Steel Industry was held March 8-10, 1955, at the William Penn Hotel, Pittsburgh, Penna. Sponsored by the Pittsburgh Section, ISA, this important affair was attended by more than 1000 engineers from all the steel centers of the United States and Canada.

Highlight of the 14-paper program was a panel discussion on Iron and Steel Instrumentation Problems, conducted by Mr. R. R. Webster of Jones & Laughlin Steel Corporation; the top "user" and "supplier" representatives of the steel industry were on this panel. Session topics were on annealing, steel mill gases, and production instrumentation.

The Exhibit was under the direction of Mr. C. F. Goldcamp, and had the same professional look as the National ISA Exhibits. A special feature of the Exhibit was a large section on electronics and nucleonics.

To A. F. Robbins (Crucible Steel), F. P. Hubbel (U. S. Steel), R. A. Francy (Weirton Steel), and A. H. Peterson (Mellon Institute) goes the credit for managing this regional conference that has now attained national stature and recognition.

Changing the Watch

Milton H. Aronson, well-known in the instrument field as editor of *Instrument & Apparatus News*, *Instrument Manufacturing*, and as technical editor of *Instruments and Automation*, has assumed editorship of the latter publication. Editor M. F. Behar, who for 25 years has guided *Instruments and Automation*, will remain active on the staff as Editor Emeritus.

Mr. Aronson's experience includes instrument engineer with Carnegie-Illinois Steel, Clairton, Pa., electronics engineer with Naval Ordnance Laboratory, Washington, D. C., and head, Electronics Section, Naval Training Publications Center, Washington. Since 1952, Aronson has been on the staff of the Instruments Publishing Company and has been responsible for its many new features.

Mr. Aronson holds a B.S. degree in Physics, 1939, from the Carnegie Institute of Technology, and has taken advanced math and operational calculus at George Washington University and the University of Maryland. He has been on the graduate instructor staff of the University of Pittsburgh and is author of the book *Electronic Circuitry for Instruments and Equipment*. He is a member of the American Institute of Electrical Engineers (Associate), Institute of Radio Engineers, Instrument Society of America, and Society of Technical Writers.

An open letter to our readers:

Dear Readers:

It is indeed an honor to assume the position held so nobly and honorably for so many years by Major M. F. Behar. "The Major," as he is affectionately known by many thousands, has made an important contribution to our field, one of the most important. Twenty-five years ago, work in the field of instrumentation was work in a small and unknown field, and the rewards were meager compared to the efforts required.

M. H. Aronson

M. F. Behar

Faith in the future of instrumentation was the driving force behind the constant efforts of "The Major," who outlined the first methodology of the field and did much of its earliest published work, who coined the word "instrumentation," who championed every worker and every development in the field. He, who called the scientists of the National Bureau of Standards the "high priests of precision," can aptly be called the first prophet of Instrumentation. His prophecies and vision have been fulfilled. Instrumentation has come of age. Ill health now prevents his carrying on as previously. but I am grateful for his presence in an advisory capacity. (At the moment he is enjoying the sunny climate of the Riviera in southern France.)

The Major has taught me many things—adherence to principle, faith in the future of instrumentation, diligence in seeking after the truth. His credo can well be described in the words of Lucretius in the poem "Concerning the Nature of Things," which your new editor accepts as a guiding principle for the future:

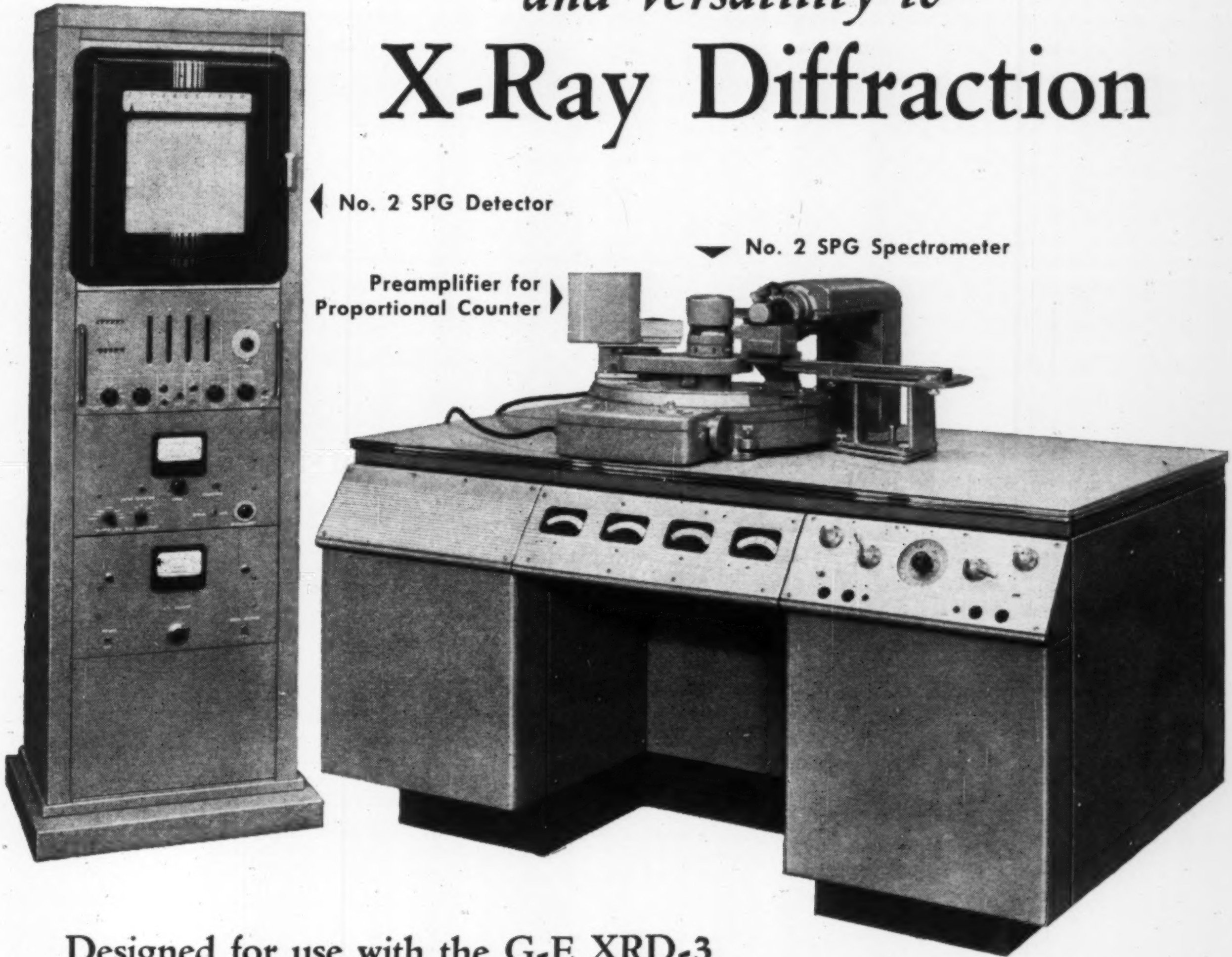
> **"Now apply your mind, I pray, to a true reasoning; for a truth wondrously new is struggling to reach your ears, and a new view of creation to reveal itself . . . ". . . your merit and the anticipated pleasure of your sweet friendship urge me to undertake any toil and induce me to keep vigil through the silent nights, searching by what words, yea and in what measures, to spread before your mind a bright light by which you may examine deeply into hidden truths . . ."**

Milton H. Aronson

New G-E Accessories

contribute greater accuracy and versatility to

X-Ray Diffraction



Designed for use with the G-E XRD-3

The G-E XRD-3 x-ray diffraction unit is widely used for physical and chemical analysis of many kinds of materials. To extend this unit's working range — and to make it even more accurate — we offer the following new accessories:

1. No. 2 SPG Detector. Unit features scaler of extended range with resolving time of one micro-second . . . with provision for both counting for preset time and timing for preset count . . . with automatic recording counter . . . with precisely adjustable long wavelength pulse discriminator to complement proportional counter. Also featured is ratemeter with both linear and logarithmic response by selector switch. Linear response contributes convenience in measuring relative intensities. Logarithmic response provides uniform measurability of widely differing intensities.

2. No. 2 SPG Preamplifier for proportional counters is designed to work with the No. 2 SPG Detector. Gas-filled proportional counter is generally preferred because of the semi-monochromating effect of the selective absorption characteristics of the gas in nearly all x-ray diffraction procedures.

3. No. 2 SPG Spectrometer uses a reflecting crystal to measure x-ray spectra of small atomic number elements in helium atmosphere. Offers vast improvement of intensities for all elements in air.

Get complete details from your General Electric x-ray representative. Call him today . . . or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, for Pub. BL44.

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle **40** on inquiry card.

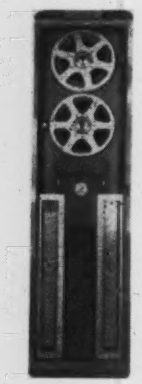
New Instruments . . .

INSTRUMENTS and AUTOMATION

For further information use the postage-free order card on page 667

RECORDING

Tape Transport Unit

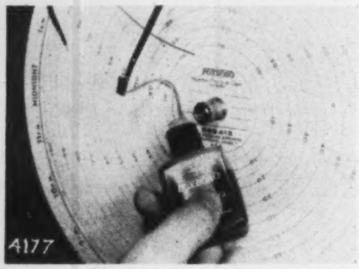


New "Model 546 Magnetic Tape Transport Unit," for use with most digital computer and data processing systems, has a capacity of 2400 feet of ½ or ¾ in. magnetic tape which is moved at optional speeds of 30, 40, 50, 60, or 75 ips. by two constant-speed capstan motors. Using a standard ¾-in. tape and Brush "Series BK1500N or BK1300N" heads, a maximum of 18 information channels is available. Through its remote features, unit will perform (with associated control) such functions as search, selective reading and writing, rapid reversal of tape direction, rewind and stop.—*ElectroData Corp., 717 N. Lake Ave., Pasadena 6, Calif.*

For more information circle **201** on inquiry card.

Recorder Ink

New "Type 1500" ink was especially formulated for use with maker's pens and "Humitex" charts to produce



sharpest possible record; contains no sediment. ★ New squeeze bottle has unique plastic capillary tube and filter assembly enabling user to dispense precise quantity without dripping. Red, violet, blue, green and black.—*The Foxboro Co., Foxboro, Mass.*

For more information circle **202** on inquiry card.

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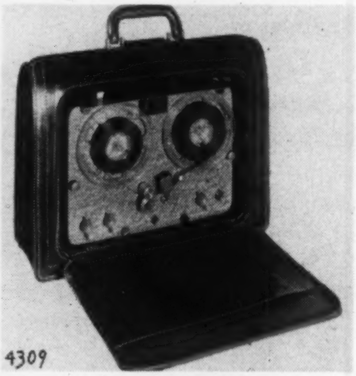
Briefcase Recorder

New "Secret Recorder" is a battery-operated magnetic tape recorder for investigative work, camouflaged in an



average-size leather briefcase which may be opened, carried or put dowr without showing quiet recorder in operation.—*Amplifier Corp. of America, 398 Broadway, New York 13, N. Y.*

For more information circle **203** on inquiry card.

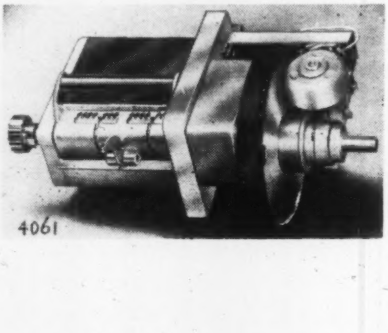
Airborne Tape Recorder

New "Series 550," smallest multi-channel airborne magnetic tape recorder yet produced, is packaged in two units 7 in. wide by 7¾ in. long. Recorder and oscillator unit is 8 in. high and weighs 15 lbs.; power supply unit is 6 in. high and weighs 10 lbs. Reels holding 450 ft. of "thin" (1.5 mil) 1-in. tape permit 6 min. of recording time at 15 ips. Standard model contains 6 FM recording oscillators on printed circuit plug-in cards having a 1 to 2000 cps. data bandwidth and one crystal-controlled reference channel oscillator; operates from 25-29 v.dc.—*The Davies Laboratories Inc., 4705 Queensbury Rd., Riverdale, Md.*

For more information circle **204** on inquiry card.

Paper Tape Readers

New "FR-300 Series" perforated tape readers, designed to read one or more standard perforated tapes at rates up to 60 characters per second,

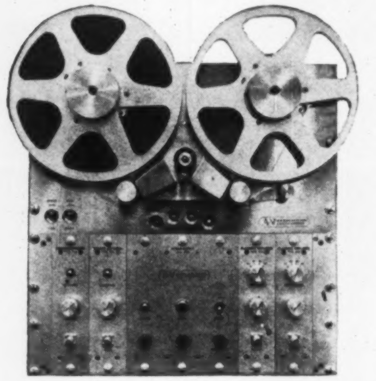


feature contoured low-inertia sensing pins, sprocket hole guiding unique single revolution clutch and Geneva drive to eliminate tape advance impact loads.—*Soroban Engineering, Inc., Box 117, Melbourne, Fla.*

For more information circle **205** on inquiry card.

Tape Recorder

New "Type 7" magnetic tape recording equipment features "Building Block" assembly and new magnetic

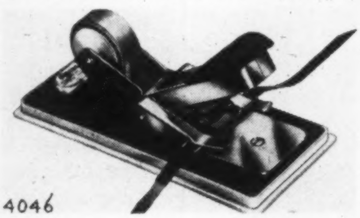


heads and drive; can record all types of instrumentation information such as vibration, shock, sound, pressure and telemetering data, etc., from 100 to 100,000 cps.—*A-V Mfg. Corp., 730 Fifth Ave., New York 19, N. Y.*

For more information circle **206** on inquiry card.

Tape Cutter-splicer

New "Gibson Girl Deluxe Model TS-4DLX" not only miter-cuts recording tape and trims spliced joint with a

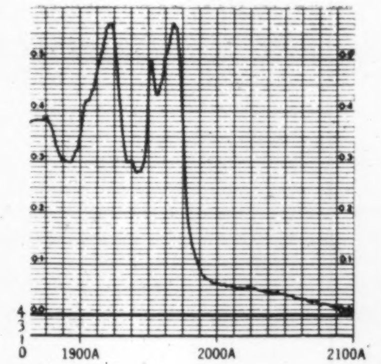


unique indented "Gibson Girl" waist, but also carries a roll of splicing tape which is fed through to point of application. Professional splices can be made in 5 sec. and no other equipment is needed.—*Robins Industries Corp., 82-09 251st St., Bellerose 26, N. Y.*

For more information circle **207** on inquiry card.

Wider-region Recording Spectrophotometer

New optical elements in maker's "Model 14" open a new wavelength region—to 0.19 micron and shorter—enabling analysis of a number of compounds "not previously adaptable to



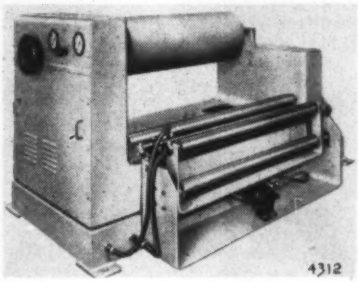
untraviolet spectrophotometry on standard instruments." Illustration: spectrum of methyl ethyl ketone vapor.—*Applied Physics Corp., 362 W. Colorado St., Pasadena, Calif.*

For more information circle **208** on inquiry card.

AUTOMATION

Web and Edge Control

New backstand controls both tension and edge position of a moving web as it is fed to a slitter, printing press, etc. Tension can be maintained at any selected value up to 4 lb./in. within 5 percent at any steady web speed. Edge position is maintained within 0.015 in. with a runout of 3 in. from center position. Speeds up to 1200 fpm.—*Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.*



For more information circle **209** on inquiry card.

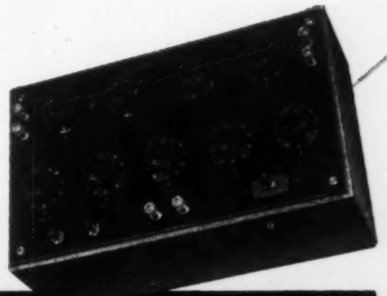
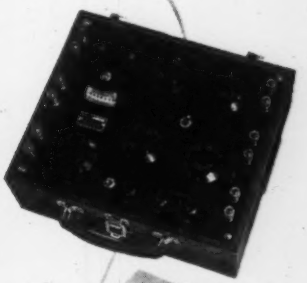
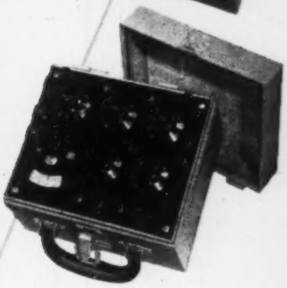
Supervisory System

New 24 point supervisory system has double operating range of previous design and a simplified adjustment of coding relay timing; is expected to fulfill more than 50 percent of all user requirements for remote control and indication for substations and small generating stations. All devices in both master and remote stations of new system are mounted on front panels. Adjustment of coding relay timing can be made by turning a rheostat knob.—*Medium Voltage Switchgear Dep't, General Electric Co., Philadelphia, Pa.*

For more information circle **210** on inquiry card.

Proportional Controller

New "AEG Swing Coil Regulator" (German-made) comprises a millivoltmeter movement carrying a coil which moves in an alternating magnetic field to produce an induced voltage

Precision WHEATSTONE BRIDGES

Highest Accuracy. . . Minimum Size for Field, Lab, and Production Use

There's a Shallcross Bridge for measuring resistance to any desired precision—indoors or out. Field models have aluminum cases with controls easily adjustable even with a gloved hand. Models for lab, production, and school use feature high readability and simple operation—even for unskilled users.

Accuracy, Stability, and Ruggedness—unsurpassed in any instrument of comparable price.

Selections from the complete Shallcross line are described below. Additional specifications on these, and many other types, are available from SHALLCROSS MFG. CO., 510 Pusey Ave., Collingdale, Pa.

Deliveries ✓ from Stock ✓

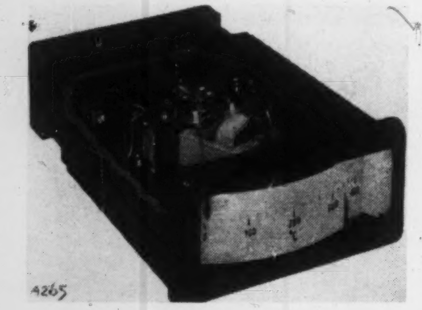
WHEATSTONE—FAULT LOCATION BRIDGE No. 6100: 5-dial field model. Locates grounds, crosses, opens, and shorts by Murray, Varley, Hilborn, or Fisher Loop and Capacitance tests. Range: 1 to 1,011,000 ohms. Accuracy: ± 0.1%, + 0.01 ohm. 8⅞" x 7⅜" x 5¾". 8 lbs. *Price: $175.*

KELVIN-WHEATSTONE BRIDGE No. 638-R: Shallcross has pioneered this compact combination of two bridges in one. Range: 0.001 to 11,110,000 ohms. Accuracy: ± 0.3% – 1 to 111,100 ohms. 12½" x 10½" x 6¾". 9 lbs. *Price: $260.*

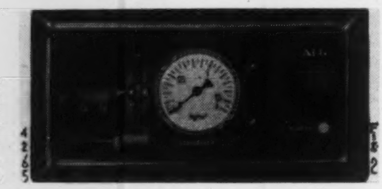
WHEATSTONE-LIMIT BRIDGE No. 6320: Combines 5-dial Wheatstone and Percent-Limit features. Range: 0.1 to 111,110,000 ohms. Accuracy—*Ratio resistors:* ±.01%, *Rheostat:* ±(.01% to .05% + .005 ohms). 15¾" x 9¼" x 5½". 15 lbs. *Price: $700.*

Shallcross

For more information circle **41** on inquiry card.



whose value is proportional to deviation from set point and whose phase depends on sign of deviation. This output is amplified by an electron tube and fed to an electropneumatic power relay (Fig. 2) which commands a diaphragm-motor valve or other final element. Controller's proportional band is adjustable from 0 to 20 percent.—*Donald O. Seibert, Box 281, Wilmington, Del.*



For more information circle **211** on inquiry card.

Telemetering Oscillator

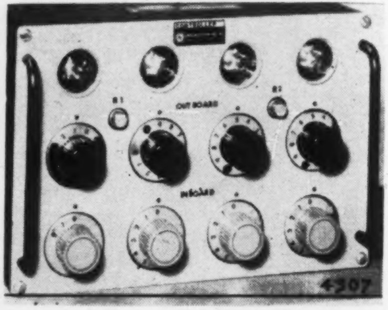
New "Series 0200" works with most variable-reluctance devices on any center frequency from 1 kc. to 100 kc. Its circuit employs a highly stable FM oscillator followed by an isolating voltage amplifier: inductance variations of device connected across oscillator tank circuit produce proportional deviation in oscillator frequency. After successful airborne uses, recommended industrial uses include measurement and control of liquid level, pressure, flow-rates, etc.—*Datran Engineering Corp.*, 6312 *W.* 92*nd St., Los Angeles* 45, *Calif.*

INDUCTANCE CONTROLLED
OSCILLATOR
MODEL
SERIAL
FREQ.
Datran
ENGINEERING CORP.
4349
INCHES

For more information circle **212** on inquiry card.

Digital-type Controller

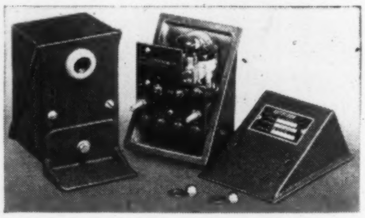
New automatic digital controller can be used to control machine tools, conveyor belts, batch mixing operations, or to hold valves within preset limits. "Heart" (illustrated) has capacity of 2500 counts; adds and subtracts at rates up to 20 digits per second. Count at any instant is shown by four of a new type of counter tube, known as "Inditron." Primary elements can be photocells, switches, etc., with discrete outputs; or thermocouples, pH cells, etc., with continuous outputs.—*American Electronic Mfg. Inc.*, 9503 *W. Jefferson Blvd., Culver City, Calif.*



For more information circle **213** on inquiry card.

Photoelectric Control

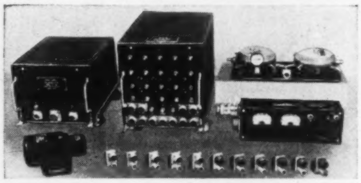
New improved photoelectric control unit is designed for applications where light beam is wholly interrupted; requires 20 foot-candles minimum light, 0.06 sec. minimum phototube dark time and 0.06 sec. minimum phototube light time. Plate relay is energized when light beam is interrupted; contacts rated 5 amps. 115 v.ac.—*The Autotron Co., P. O. Box 722-Q, Danville, Ill.*



For more information circle **214** on inquiry card.

Gas Detector

New "Model GG/102," for making quantitative measurements of gas concentrations in certain mixtures of gas and air, derives operation from fact that certain gas and air mixtures (below lower explosive limit) will burn in presence of a heated platinum filament and tend to further heat filament. Among features: continuous sampling at ten test locations; ½-second response; compensation system permitting operation over wide ranges of temperature and pressure.—*Bristol Engineering Corp., Bristol, Penna.*

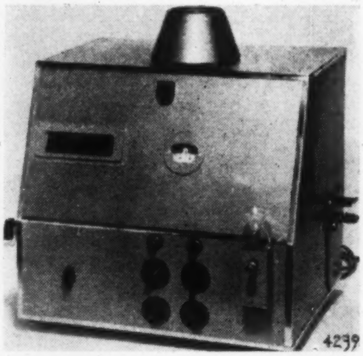


For more information circle **215** on inquiry card.

FLAME PHOTOMETERS

Flame Photometer

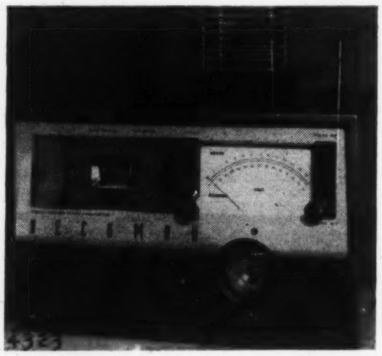
New "Norelco Internal Standard Flame Photometer," for rapid analysis of sodium, potassium and lithium, measures sodium and potassium in blood urine and tissue; detects alkalies in cement; detects alkalies in silicates and metals; detects lithium oxide in cement; analyzes water and water-formed deposits. One feature permits both Na and K to be determined sequentially in each specimen as it passes through instrument; another is that each element is detected by a photocell of maximal sensitivity for that element.—*Mount Vernon Div., North American Philips Co., Inc.*, 750 *S. Fulton Ave., Mount Vernon, N. Y.*



For more information circle **216** on inquiry card.

Flame Photometer

New Flame Photometer features simplified operation and an indicator calibrated directly in milliequivalents of sodium and potassium (no need of referring to calibration curves or conversion tables). Moving Na or K lever into position automatically places proper filter between flame and phototube and brings correct calibration pots into operating position. Indicated range 0 to 2.8 meg/l. for Na and 0 to 0.14 meg/l. for K. User can soon make 50 to 60 determinations per hour.—*Beckman Div., Beckman Instruments, Inc., Fullerton* 1, *Calif.*

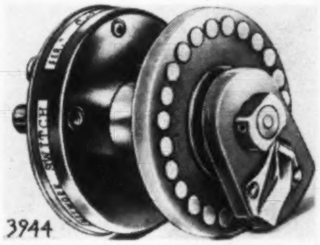


For more information circle **217** on inquiry card.

TEMPERATURE

TC Transfer Switches

New thermocouple transfer switches feature contact resistance of less than 0.004 ohm (will not vary more than 0.0003 ohm over life of unit). Available in all combinations of poles per deck, number of decks and positions per deck. Silver alloy contacts, slip rings and rotor arms: therefore no thermal emf.—*The Daven Co., 191 Central Ave., Newark 4, N. J.*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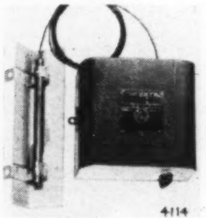
For more information circle **218** on inquiry card.

Heating Controller

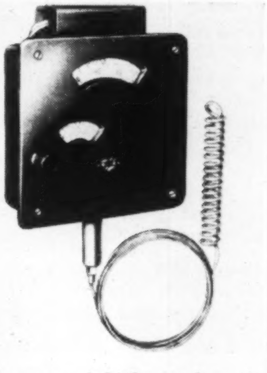
New "Weather-Man" for multiple occupancy buildings has a remote outside-temperature bulb; program dial automatically controls heat input during the day, provides night setback and a morning buildup period—all adjusted according to changes in weather. Manual "Variator" dial alters heat flow in case of special requirements. A hand switch is also provided for manual operation without disturbing dial program.—*Automatic Devices Co., Inc., Western Springs, Illinois.*


4114

For more information circle **219** on inquiry card.

Temperature Controller

New "Type E32N" replaces "E8N." Among new features: calibrating mechanism compensates movement errors of commercial thermal systems, permitting replacement of these systems in the field without loss of calibration accuracy; 12-in. scale rotates against a fixed index pointer; each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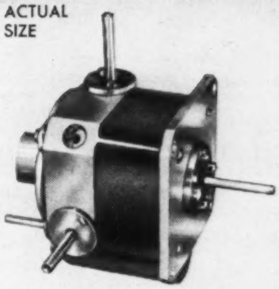
TWO NEW KEARFOTT COMPUTER COMPONENTS

MINIATURE MECHANICAL RESOLVER


1/2 ACTUAL SIZE

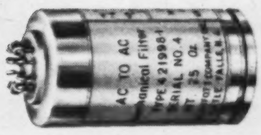
An extremely compact unit measuring only 1 15/16" high, 1 3/4" wide and 2 1/8" long. It combines the functions of a ball and disc integrator and a spherical resolver. Will integrate the sine and cosine functions of an angle or resolve a vector displacement into its horizontal and vertical components.

INTEGRATING FILTER

Used to integrate a voltage signal from a specified minimum integration period to one approaching an infinite period of time. Available for DC to AC or AC to AC applications. These units eliminate harmonic and quadrature voltages to the servo motor driving a tachometer generator. Permits the use of a low gain, non-critical amplifier by effectively providing infinite gain.

DIMENSIONS:

AC-AC Filter 1.437" diam. x 2.484" long.
DC-AC Filter 1.969" diam. x 2.938" long.



1/2 ACTUAL SIZE

The close attention to details that has made Kearfott one of the leading producers of servo system components goes into the design and production of these devices. Detailed descriptions sent on request.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

ENGINEERS:

Many opportunities in the above fields are open—please write for details today.

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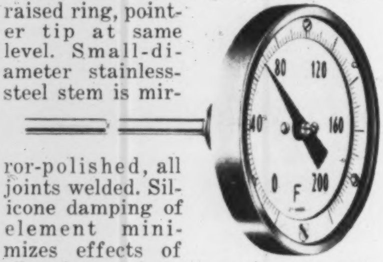
For more information circle **42** on inquiry card.

model automatically compensated for ambient and overtravel temperatures. Twelve standard models; spans from 300 F. or 550 F. between limits of –150 F. to 650 F. with on-off differential as close as 0.5 F. Electrical ratings 15 and 20 amps.—*United Electric Controls Co., 85 School St., Watertown 72, Mass.*

For more information circle **220** on inquiry card.

Dial Thermometer

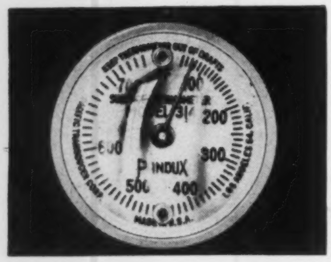
New all-stainless-steel bimetal dial thermometer features anti-parallax "Maxivision" dial: graduations on a raised ring, pointer tip at same level. Small-diameter stainless-steel stem is mirror-polished, all joints welded. Silicone damping of element minimizes effects of vibration and acts as heat-transfer medium. Ranges from minus 80 F. to 1000 F.; dials graduated in F. or C.—*Manning, Maxwell & Moore, Inc., Stratford, Conn.*

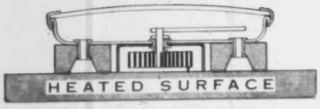


For more information circle **221** on inquiry card.

Surface Thermometer

New "Model 314" surface temperature thermometer, range 50 to 750 F., features bimetal spiral metals specially designed for high temperatures; is affixed to surface by means of two Alnico magnets.—*Pacific Transducer Corp., 11836 W. Pico Blvd., Los Angeles 64, Calif.*

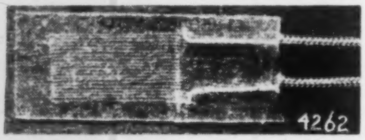




For more information circle **222** on inquiry card.

Thermometric Resistor

New "SN-1," added to "RdF Stikon" line of resistance-thermometer elements, features silicone-impregnated glass-fiber fabric which permits continuous operation at 500 F. and short-term use at 600 F. It measures 9/16 by 1-7/16 by 0.01 thick and weighs (excluding external leads) a little less than 0.005 oz.: approx. weight of two ordinary postage stamps. At 70 F., resistance is 100 ohms; manufacturing tolerance is 2 ohms; each element marked to nearest 0.5 ohm.—*Ruge-De Forest, Inc., 50 Moulton St., Cambridge 38, Mass.*



For more information circle **223** on inquiry card.

Thermocouple Heads

New compact watertight thermocouple heads with chrome finish for corrosion resistance are easy to assemble (screws loosened, not removed); are 2-5/32 in. long by 1⅛ in. diam.; weight 3½ oz.—*Conax Corp., 4515 Main St., Buffalo 21, N. Y.*

For more information circle **224** on inquiry card.

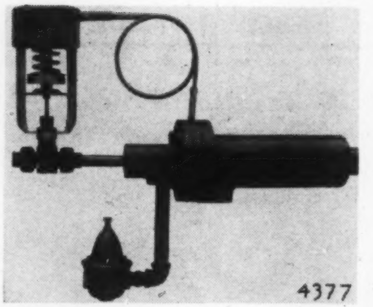
Safety Shut-off

New "AR-100R" thermopilot relay for automatic safety shutoff of gas-fired appliances is said to offer "the ultimate in convenience;" features automatic reset and exceedingly stable operation. Any tendency to chatter because of vibration is eliminated by use of maker's "G-250 Pilot Generator," which supplies ten times the voltage of ordinary single thermocouples of the same physical size.—*General Controls Co., Glendale, Calif.*

For more information circle **225** on inquiry card

Steam-and-water Mixer

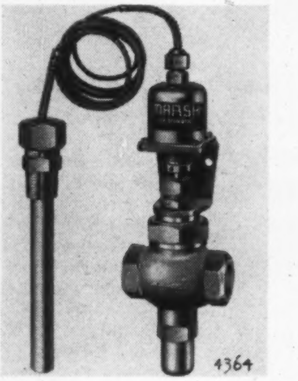
New "No. 1360 Series" utilizes full heat energy by injecting steam directly into water, can be used wherever hot water is required, and steam and water are available. Features: new bulb design with twice the surface area of conventional bulbs; mixing chamber designed to prevent stratification and false temperature indications.—*Fulton Sylphon Div., Robertshaw-Fulton Controls Co., Box 400, Knoxville, Tenn.*



For more information circle **226** on inquiry card.

Temperature Controllers

Two new temperature controllers: "Type WT" (illustrated) controls flow of brine, etc., used in cooling and other processes; its valve opens with temperature rise. Available in direct-operated sizes of ⅜, ½ and ¾ in. F.P.T. and in pilot-operated sizes of 1 to 4 in. "Type HT" controls flow of hot water or low-pressure (to 150 psi.) steam; its valve closes with temperature rise. Connection sizes: direct-operated type ⅜, ½, and ¾ in., pilot-operated type 1, 1¼, 1½ and 2 in. Various types of bulbs.—*Electrimatic Co., Skokie, Illinois.*

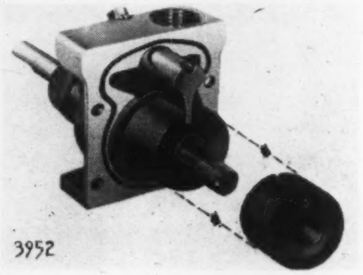


For more information circle **227** on inquiry card.

FLOW

Chemical Pump

New models of maker's gearless multi-purpose rotary type displacement pump are available with a self-lubricating carbon-graphite impeller. Among advantages: high resistance to thermal shock makes possible temperature ranges from –70 F. to 400 F.; speeds up to 5000 rpm. with non-lubricating fluids such as water or alcohol; no product contamination.—*Eco Engineering Co., 12 New York Ave., Newark 1, N. J.*



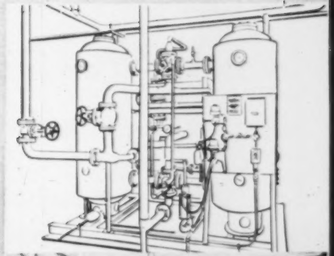
For more information circle **228** on inquiry card.

Explosion-proof Lighting for Area-type Flowmeters

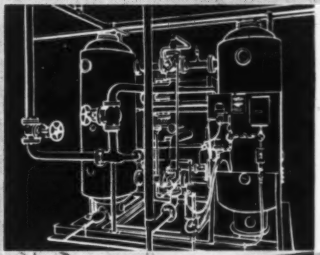
New equipment is believed to be the first explosion-proof fluorescent direct lighting system for industrial and laboratory flowmeters; is designed for translucent plastic instruments meter-

Circle **43** on inquiry card. →

10 REASONS WHY THE PRITCHARD HYDRYER IS THE ANSWER FOR INSTRUMENT AIR DRYING

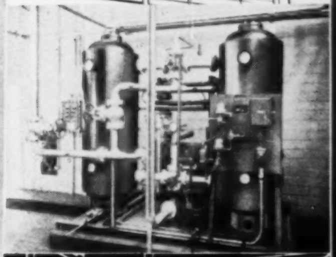


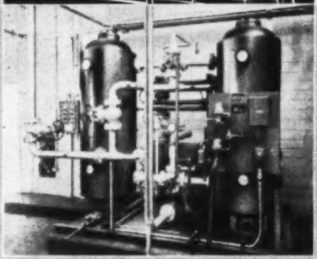
1. NO WASTE. 100% of all gas entering the HYDRYER is dried without loss.



2. FULL LINE PRESSURE REACTIVATION. Pressuring and de-pressuring of adsorbers between cycles is eliminated.

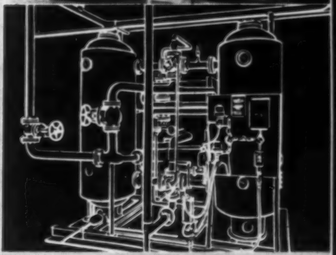
3. PURGING ELIMINATED. The Type A HYDRYER uses the inlet main gas stream for reactivation, not an external stream of atmospheric air or other gas.





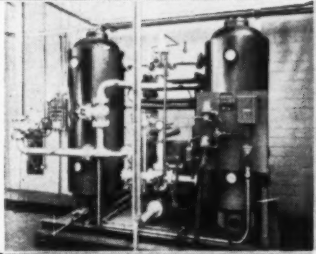
4. LONGER ADSORBENT LIFE. Dusting and breakage of particles is reduced because there is no movement of adsorbent due to pressure changes or high velocities.

5. REACTIVATION GAS IS PREHEATED. This assures complete heat transfer during the heating period for uniform reactivation of the adsorbent.



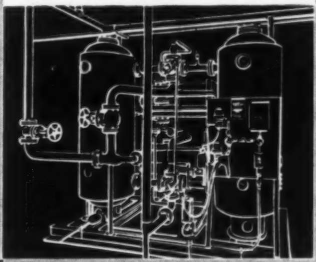
6. NO MOVING PARTS. No operating or maintenance costs on blowers, motors, fans, rotating beds . . . because there are none.

7. SIMPLIFIED OPERATIONS. The process is greatly simplified, requires minimum of operations. Important, when you have inexperienced operators.

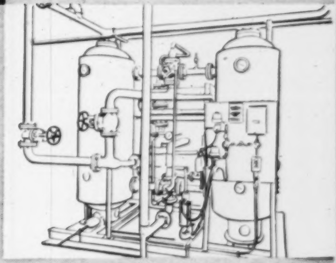


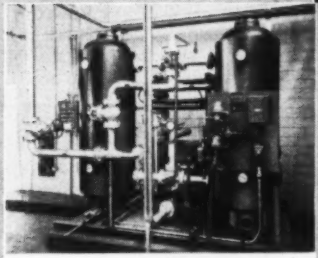
8. REDUCED EQUIPMENT AND LINE SIZES. Equipment and line sizes are small compared to those required for reactivation at atmospheric or lower pressures.

9. SAFETY FACTORS MINIMIZE HUMAN ERROR. No equipment can be damaged by opening the wrong valve.



10. VISUAL OBSERVATION and check of the moisture adsorbed from the gas stream is possible on each cycle.





HYDRYER ON DUTY, drying instrument air at the Farmers Union Exchange Refinery, Laurel, Montana. It dries 400 SCF/M of air at 60 psig and 80-95°F. saturated. Outlet gas dew point is —40°F.

SEND FOR BULLETIN

You can learn about the many ways HYDRYERS may be used to dry instrument air from this Pritchard bulletin, No. 16.0.181. Send for your complimentary copy today on your company letterhead.

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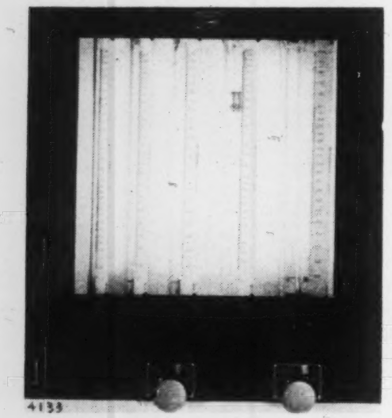
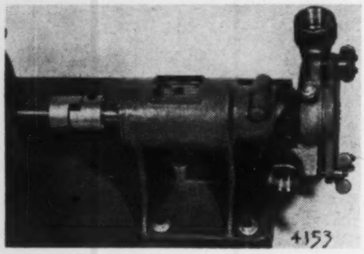


ing combustible liquids in areas where better lighting is required than provided by usual indirect or reflected methods.—*Commercial Research Labs., Inc., 20 Bartlett St., Detroit 3, Mich.*

For more information circle **229** on inquiry card.

Chemical Pump

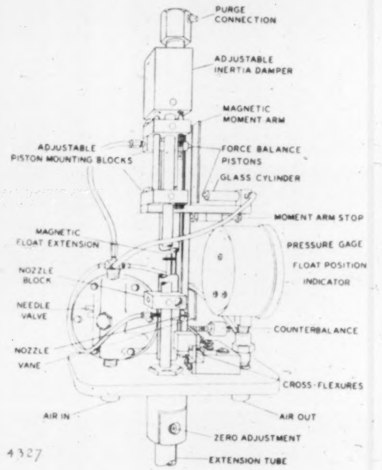
New model of stainless steel "Centri-Chem" pump is available with a new pedestal mount designed to permit belt drive or direct coupling with any standard motor. It is a centrifugal monometallic pump manufactured in Type 20 alloy, AC1 CN-7MCu.—*ECO Engineering Co., 12 New York Ave., Newark, N. J.*



For more information circle **230** on inquiry card.

Flow Transmitter

New "Mag/Nu/Matic" magnetically-actuated pneumatic transmitter, for use with all types of pneumatic receivers and control instruments, employs a force-balance pneumatic system featuring low inertia and rapid response; operates at flow rates as low as 0.5 gpm. of water or 2.0 cfm. of air. Low float mass permits operation at low pressure drop.—*Brooks Rotameter Co., Lansdale, Penna.*


PURGE CONNECTION
ADJUSTABLE INERTIA DAMPER
MAGNETIC MOMENT ARM
ADJUSTABLE PISTON MOUNTING BLOCKS
FORCE BALANCE PISTONS
GLASS CYLINDER
MOMENT ARM STOP
MAGNETIC FLOAT EXTENSION
PRESSURE GAGE
FLOAT POSITION INDICATOR
NOZZLE BLOCK
NEEDLE VALVE
COUNTERBALANCE
NOZZLE
VANE
CROSS-FLEXURES
AIR IN
AIR OUT
ZERO ADJUSTMENT
4327
EXTENSION TUBE

For more information circle **231** on inquiry card.

Chemical Pump

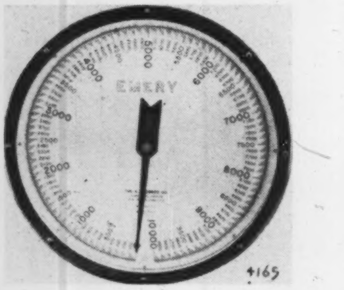
New "Type MSM" positive-displacement reciprocating type pump, for chemical injection, proportioning, etc., operates on air or gas pressure; provides discharge ratios up to 497:1, so that almost 25,000 psi. discharge pressure may be obtained with 50 psi. operating pressure; can be regulated to inject additives in exact proportions to volumes carried in lines or vessels.—*Texsteam Corp., P. O. Box 9127, Houston, Texas.*

For more information circle **232** on inquiry card.

PRESSURE

Large-dial Gage

New 19½-in. Bourdon pressure gage provides increased accuracy, greater visibility, and easier reading. When used with maker's load cells, guaranteed accuracy is 2 percent of load range. Scales individually calibrated at twenty points. Various standard and special scales, top center dials, etc.—*The A. H. Emery Co., New Canaan, Conn.*



For more information circle **233** on inquiry card.

Pressure Switches

New miniature (4 oz.) pressure switches handle 5 to 12,000 psi.; meet or surpass military specs for performance, vibration, etc.; available in sp.st., sp.dt., 2p.s.t., 2p.dt., N-O or N-C; 17 amp. at 24 v.dc., 15 amp. at 115 v.ac.—*Leach Relay Co., 5915 Avalon Blvd., Los Angeles 3, Calif.*

For more information circle **234** on inquiry card.

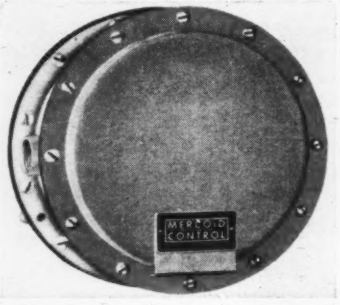
Vacuum-gage Tube

New vacuum-gage tube of thermocouple type is designed to retain permanent calibration while withstanding intense vibration, shock and temperature change; is for use with maker's vacuum indicator and indicator-controller in 1-1000-micron range. Short butt-welded noble-metal thermocouples are arranged in a thermopile to compensate for temperature changes and for rate-of-change of temperature Welded construction makes gage tube resist damage by vibration. Matched tubes can be used for multi-point monitoring from a single gage. Tubes respond in one-half second; employ standard ⅛-in. IPS male threads.—*Hastings Instrument Co., Hampton, Va.*

For more information circle **235** on inquiry card.

Weatherproof Diaphragm Pressure Controllers

New "Series PQW and PPQW," for control of low pressure or vacuum (inches or hundredths of inches of water) are suitable for outdoor service. Equipped with maker's Sealed Magnetic Mercury Switch, capacity 20 watts. "PPQW" is for differentials.—*The Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.*


MERCOID CONTROL

For more information circle **236** on inquiry card.

Pressure Pickup

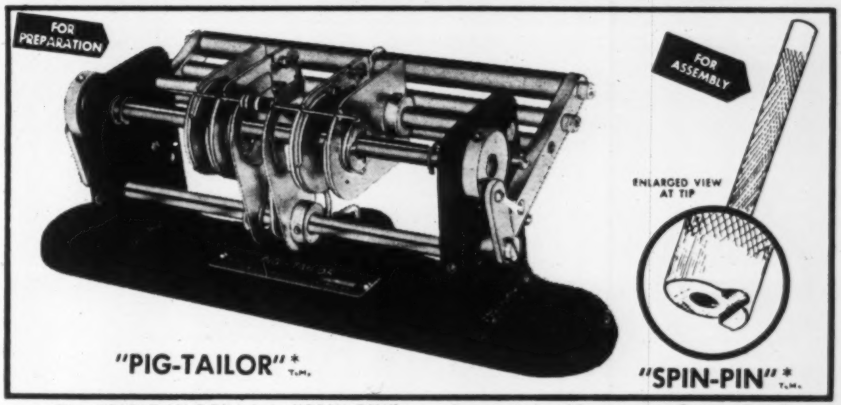
New "Model DP-15" utilizes variable reluctance principle for static and

Half actual size
NORTHAM
MODEL DP-15
RANGE 1000 PSI
SER 302
4238

"PIG-TAILORING"

. . . . *a revolutionary new mechanical process for higher production at lower costs. Fastest PREPARATION and ASSEMBLY of Resistors, Capacitors, Diodes and all other axial lead components for TERMINAL BOARDS, PRINTED CIRCUITS and MINIATURIZED ASSEMBLIES.*

● ● ● ● ●



The "PIG-TAILOR" plus "SPIN-PIN" — Accurately Measures, Cuts, Bends, Ejects and Assembles both leads simultaneously to individual lengths and shapes — 3 minute set-up — No accessories — Foot operated — 1 hour training time.

PIG-TAILORING provides:

1. Uniform component position.
2. Uniform marking exposure.
3. Miniaturization spacing control.
4. "S" leads for terminals.
5. "U" leads for printed circuits.
6. Individual cut and bend lengths.
7. Better time/rate analysis.
8. Closer cost control.
9. Invaluable labor saving.
10. Immediate cost recovery.

PIG-TAILORING eliminates:

1. Diagonal cutters.
2. Long-nose pliers.
3. Operator judgment.
4. 90% operator training time.
5. Broken components.
6. Broken leads.
7. Short circuits from clippings.
8. 65% chassis handling.
9. Excessive lead tautness.
10. Haphazard assembly methods.

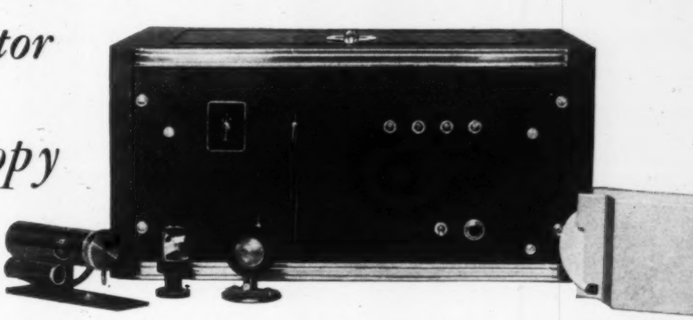
* PATENT PENDING

Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. IA 4-P

BRUNO-NEW YORK INDUSTRIES CORPORATION
DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT
460 WEST 34th STREET • NEW YORK 1, N. Y.

For more information circle **44** on inquiry card.

A Superior Detector for Infra-Red Spectroscopy



GOLAY PNEUMATIC DETECTOR

Among the characteristics that render the Golay Detector superior to other types of detectors for use in infrared spectroscopy are:

1. **An effective sensitive area 3/32" in diameter.**
2. **Sensitivity of 6×10^{-11} watts RMSENI when used with "chopped beam" method and with recording time constant of 1.6 second.**
3. **Uniform sensitivity from the ultra-violet through the visible and the entire infra-red, and up to the micro-wave region.**
4. **Improved, drift-free, A.C. operated amplifier with step gain controls and four response periods.**

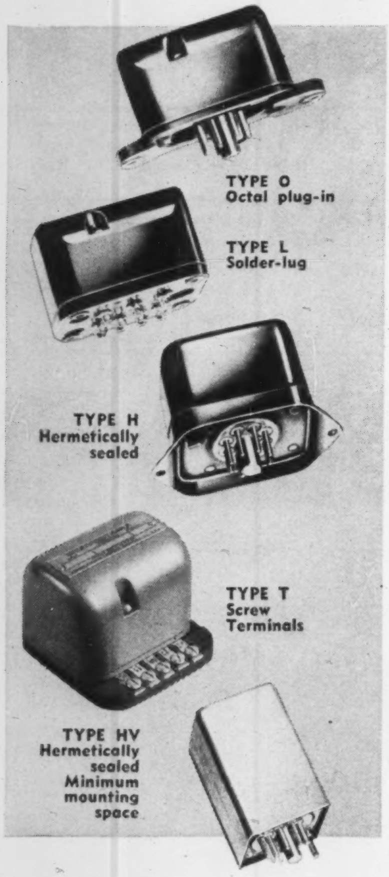
Write for EPLAB Bulletin No. 10

THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
2 SHEFFIELD AVENUE, NEWPORT, RHODE ISLAND, U.S.A.

For more information circle **45** on inquiry card.

BARBER COLMAN **ultra-sensitive relays**

help solve control problems in wide range of industrial applications



Operating on input powers of 50 to 1000 microwatts, the Barber-Colman Micropositioner is ideal for use as a null detector in resistance bridge circuits, a differential relay in electronic plate circuits, and an amplifier in photo-electric circuits. Standard contact arrangement is SPDT, null seeking. Can be operated in excess of 100 cps. This ultra-sensitive polarized d-c relay has been widely used in many control applications . . . in nucleonics, communications, instrumentation, process control, railway signal transmission, and aircraft temperature control and remote positioning. Write for Bulletin F 3961-4.

Barber-Colman Company

Dept. P, 1415 Rock Street, Rockford, Illinois

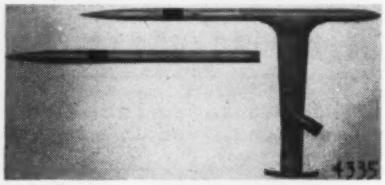
For more information circle **46** on inquiry card.

dynamic measurements of differential pressure in ranges from ± 200 to ±5000 psid. at line pressures up to 5000 psi; stand overloads up to 100 percent. Natural frequencies from 2000 cps. at lowest range to 10,000 cps. at highest.—*North American Instruments, Inc.,* 2420 *N. Lake Ave., Altadena, Calif.*

For more information circle **237** on inquiry card.

Air Blast Pickups

Three new barium titanate air blast gages measure true free-field pressure; can be supplied with or without strut-mounting; provide high sensitivity (250 mv./psi.), broad frequency range (1 cps.-100 kc.) and wide dynamic range (to 1000 psi.); are suitable for general transient pressure measurements in gases as well as for shock-wave studies.—*Chesapeake Instrument Corp., Shadyside, Md.*



For more information circle **238** on inquiry card.

Air Regulator

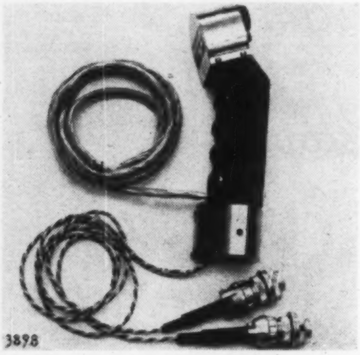
New "Model 55 Regulator" provides drift-free source of clean, dry air for instrument service or air-regulated equipment. Capacity up to 15 scfm.; maximum inlet pressure 150 psi.; automatic relief if the regulated pressure exceeds pre-set value. Resinous bonded filter element 35 times area of standard ¼-in. pipe. Entire unit easily cleaned; dripwell drained by a simple push-button valve.—*Kendall Controls Corp.,* 144 *Moody St., Waltham, Mass.*

For more information circle **239** on inquiry card.

FORCE, ACCELERATION

Stick-force Dynamometer

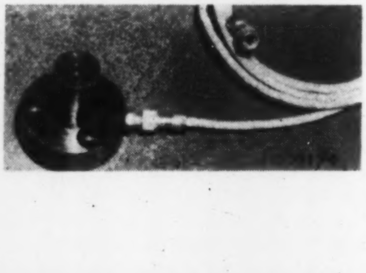
New "R1040-2," used with maker's "Servometer" to measure forces applied to aileron and elevator controls, is a double-cantilever beam dynamometer employing two strain gage bridges, each with four active arms. Voltage outputs of strain gage bridges are independent of load distribution applied to grip. (Original design work was by Wright Air Development Center.)—*Radiation, Inc., Melbourne, Fla.*



For more information circle **240** on inquiry card.

Acceleration Pickup

New "Glennite Model A 330" withstands up to 30,000 *G* without damage; is for research in drop testing and impacts of projectiles; utilizes a piezoelectric ceramic said to provide better linearity and temperature stability than pure barium titanate. New rugged-type seismic suspension and titanium construction throughout achieve compactness (1¾ in. diam. by 1-5/32 in. high); weight 1¼ oz. exclusive of cable.—*Gulton Mfg. Corp., Metuchen, N. J.*



For more information circle **241** on inquiry card.

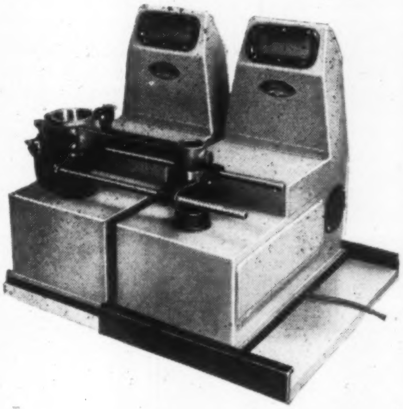
Strain Indicator

New "Type RS-20" features resistance and capacitance balancing controls, making possible the use of cables up to 500 ft. long and obviating need to add or subtract tare readings; is available in 2, 6 or 12 channels; operates with strain-gage-type pickups utilizing carrier excitation. Strain indication accuracy 1 microinch per inch. Self-contained batteries and power supply.—*Hathaway Instrument Co.,* 1315 *S. Clarkson, Denver, Colo.*

For more information circle **242** on inquiry card.

Strain-gage Control

New "Type 335" is for use with any CRO using suitable preamplifiers, or directly with maker's "Type 324." It contains necessary battery supplies and balance system to operate whatever strain-gage setup may be used. Precision calibrating resistances for



How EXACT WEIGHT Scales are used to Inspect, Balance Rods

This pair of Exact Weight SHADOGRAPH Scales is designed for use in the production of connecting rods. Shown above they are making final inspection of finished rod for weight distribution. In the forging operation, they check wear on dies. In milling, they check the amount each end is out of balance and determine correct adjustment for milling machine. They are also incorporated in many modern milling machines for completely automatic correction.

These are a few of the many applications where EXACT WEIGHT scales provide the metal working industry with methods for inspecting, check-weighing and controlling products to predetermined weight specifications. Feel free to call on our engineering service for help in solving any weighing problem.

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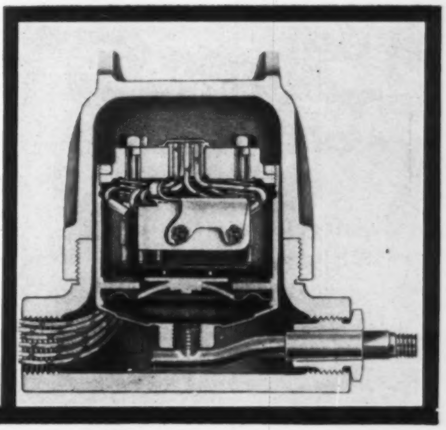
Please send details on rod balancing scales.

Name ....
Address ....
City.. Zone........... State................

For more information circle **158** on inquiry card.

New Improved

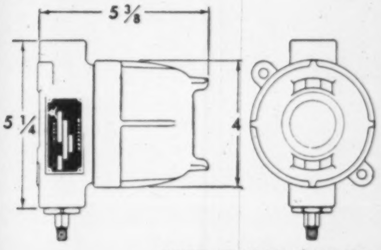


MELETRON PRESSURE SWITCH

for Explosive Atmospheres

- **LOW COST**
  because of design simplicity
- **SMALL and COMPACT**
  for easy installation
- **EXTREME ACCURACY**
  moving and wearing parts are eliminated
- **NOT AFFECTED BY VIBRATION**
  no liquid switching elements are used
- **RUGGED and WEATHER RESISTANT**
  enclosed in a crouse-hinds case
- **EASILY ADJUSTABLE**
  by convenient adjusting nut
- **OPERATES IN ANY POSITION**
  saves installation time

ACTUAL SIZE



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For more information circle **47** on inquiry card.

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For more information circle **48** on inquiry card.

multiplying factors from 0.1 to 100 can be switched in to calibrate bridge in microinches/inch.—*Allen B. Du Mont Laboratories, Inc.,* 760 *Bloomfield Avenue, Clifton, N. J.*

For more information circle **243** on inquiry card.

Acceleration Pickup

New "Model 602A" meets requirements of jet aircraft and missile applications; features an air-damped

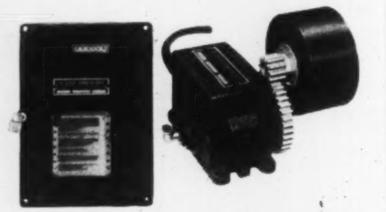
spring-mass system "eliminating for all practical purposes side acceleration effects." Damping ratio adjustable between 0.1 and 1.0 critical within a tolerance of 0.05 critical. Life expectancy 1,000,000 cycles. Recommended for use where total ranges are less than 20 G.—*Bourns Labs.,* 6135 *Magnolia Ave., Riverside, Calif.*

For more information circle **244** on inquiry card.

SPEED, TIME

Speed Recorder

New improved model of maker's "Type R-500" records speeds or production rates and totalizes production

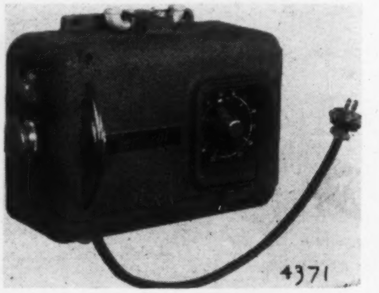


units on digital counter. Chart may be calibrated in rpm., fpm., mph., pieces or packages per minute or per hour, etc. It is inkless: wax-coated and inscribed with a stylus.—*The Electric Tachometer Corp.,* 2218 *Vine St., Philadelphia* 3, *Pa.*

For more information circle **245** on inquiry card.

Cycle-repeat Timer

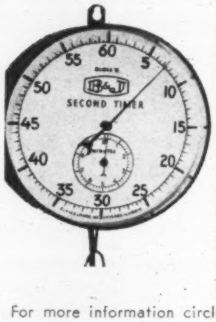
New "Type D494A Meritrol" combines an automatic-reset electrical timer with solenoid valve, pushbutton



station and signal light, for timed operation of machines or processes. Once desired time has been set, cycles will repeat as initiated by pushbutton, without further adjustment. Pushbutton serves an additional function besides starting: it can be used also as an emergency stop, opening circuit to solenoid valve for as long as held, but not resetting timer.—*Emmett Machine & Mfg. Inc.,* 445 *E. Turkeyfoot Lake Road, Akron* 19, *Ohio.*

For more information circle **246** on inquiry card.

Ten-minute Timer

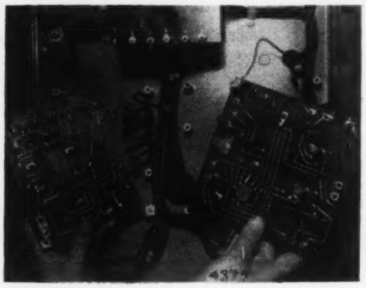


New "Giant Timer" for darkroom, laboratory, factory, etc., has 8-in. dial for 60 sec., smaller dial for 10 min. Can be stopped or started without resetting to zero; has instantaneous zero reset button. —*Burke & James,* 321 *S. Wabash Ave., Chicago* 4, *Ill.*

For more information circle **247** on inquiry card.

Variable-speed Drives

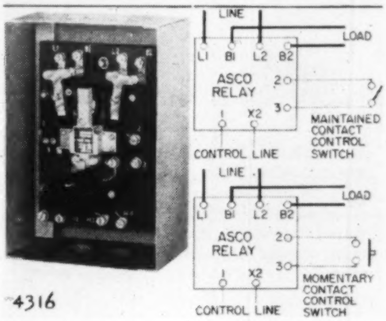
New line of full-wave "Thy-motrol" electronic adjustable-speed drives feature printed circuitry and a new, simplified control system; can be visually inspected for circuit faults since panels are actually current-carrying diagrams. New control circuit uses one miniature-type control tube (three conventional sized tubes in previous models). Available in two ratings:



¾ to 1-hp., and 1½ to 3-hp. full-wave.—*Specialty Control Dep't, General Electric Co., Schenectady 5, N. Y.*
For more information circle **248** on inquiry card.

Power Timer

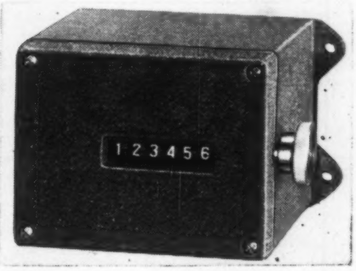
New "188539 Time Delay Relay" provides any delay from ½ to 6 seconds for all standard a.c. voltages; also for d.c. Feature: it combines a time delay relay and a contactor; can handle motor loads directly. In some applications, dynamic braking for a-c. motors without a separate d-c. source is said to be "economically practical for the first time."—*Automatic Switch Co., Orange, N. J.*
For more information circle **249** on inquiry card.


4316
LINE
LOAD
L1
B1
L2
B2
ASCO RELAY
2
3
1
X2
MAINTAINED CONTACT CONTROL SWITCH
CONTROL LINE
MOMENTARY CONTACT CONTROL SWITCH

COUNTING, COMPUTING

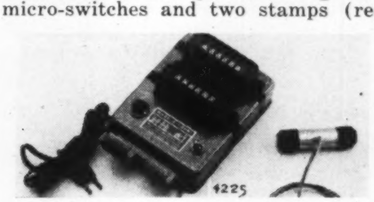
Heated Closed Counter

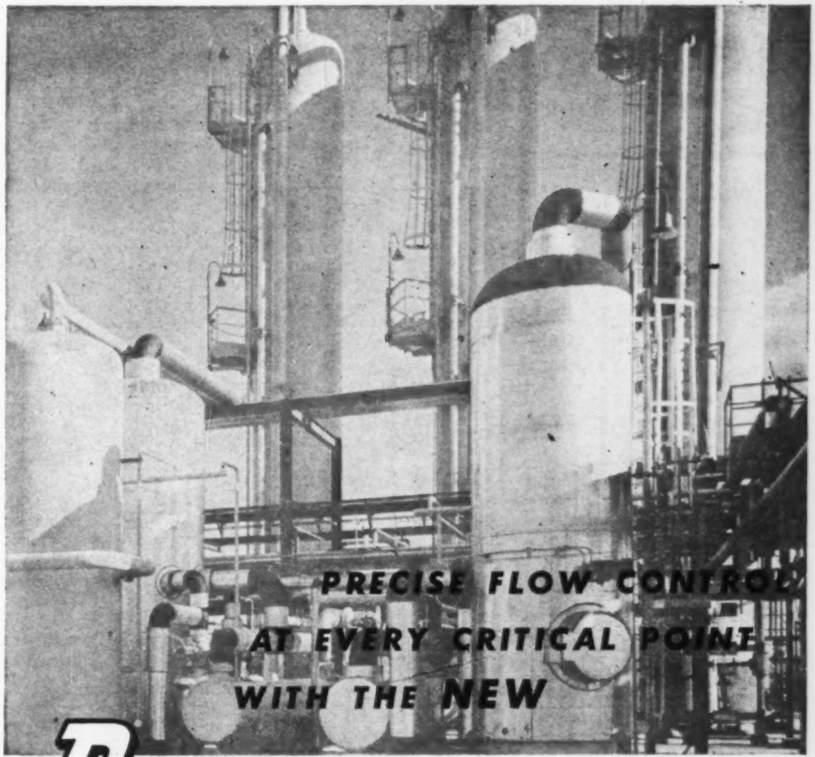
New enclosed electric counter has built-in heating element for use where dampness and temperature variation cause condensation and destructive corrosion.—*Production Instrument Co., 702 W. Jackson Blvd., Chicago 6, Ill.*
For more information circle **250** on inquiry card.



Marking-&-counting Device

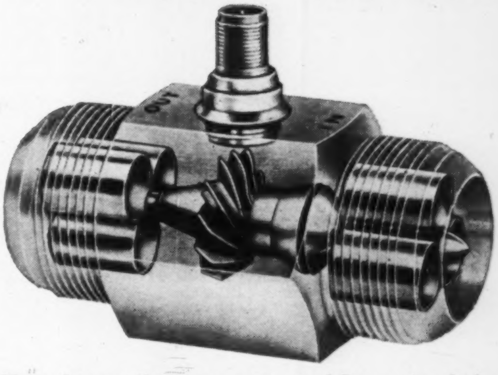
New model of "Mark-N-Count" marks, counts, and differentiates between marks and counts. It features a double-ended stamp containing two micro-switches and two stamps (red





Potter FLOW METER

Patented Potter Electronic Sensing Element utilizes frictionless "floating rotor"... is inherently linear for sustained accuracy over a wide range of flow rates.



● The Potter Electronic Flow Meter is an entirely new concept of flow meter design, already the standard of precision in aeronautical research, where even fractional errors can be disastrous.

Installed at any angle, it measures small or large quantities of acids, caustics, suspensions, slurries and other hard-to-handle liquids at temperatures to 1200°F and pressures to 35,000 psi **with ± ½% accuracy!** Flow is measured in weight or volume units via electrical impulses induced by the turbine-type sensing element.

Potter Flow Meters are simple and economical to install, trouble-free in operation, low in maintenance. Complete Potter systems are available with Indicators, Recorders and Totalizers (for automatic sequencing of batch operations) or Telemeters.

Write for Bulletin S-1.

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For more information circle **49** on inquiry card.

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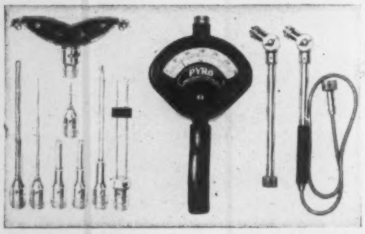

THE NEW
PYRO
Surface Pyrometer
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The NEW PYRO Surface Pyrometer has been designed to meet all plant and laboratory surface and sub-surface temperature measurements. Has large selection of thermocouples and extension arms — all interchangeable without adjustment. Quick acting, accurate, light-weight and rugged. It features a large 4¾" direct reading scale, automatic cold end junction compensator and a shielded steel housing—all combined to offer the highest precision, accuracy, dependability and durability. Available in five standard temperature ranges from 0-300°F to 0-1200°F.

Ask for Catalog No. 168 for full details.

For more information circle **51** on inquiry card.

and black) of porous self-inking type. In instrument, counters are identified by red or black bands and register number of red or black stamps.—*The May Engineering Co., 6055 Lankershim Blvd., North Hollywood, Calif.*

For more information circle **251** on inquiry card.

Digitizer

3
5
ELECTRO-MEC Laboratory, Inc.
DIGITOMETER
4368

New type of maker's "Digitometer" analog-digital rotary converter features low shaft torque (0.15 oz.-in.) in transposing rotary motion into equivalent binary numerical notation; has an unambiguous output using a reflected binary, or Gray Code, of 8 digits. Maximum recommended speed 650 rpm.; specified accuracy maintained for over 5,000,000 cycles. Weight 3 oz.—*Electro-Mec Laboratory, Inc., 21-09 43rd Ave., Long Island City 1, N. Y.*

For more information circle **252** on inquiry card.

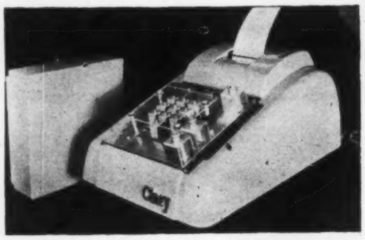
Office Computer

New "Director 600" is said to have been "especially designed to meet the ever increasing demands for a medium-priced accounting machine from the wide market that seeks a front feed carriage and accumulated proof total."—*Burroughs Corp., Detroit 32, Mich.*

For more information circle **253** on inquiry card.

Ten-key Readout

New ten-key digital read-out machine is available in four basic models: "Models 1902 and 1903," 8- and 10-column printers; "Models 1972 and 1973," 8- and 10-column printers with credit balance accumulator. Pulses can be entered into amount solenoids at speeds up to 40 milliseconds total pulse resolution with 20 milliseconds on time.—*Clary Multiplier Corp., San Gabriel, Calif.*



For more information circle **254** on inquiry card.

Digital Indicator

New "Binary Decimal Converter" provides an in-line visual display as well as control for machine storage of the decimal numbers; accepts binary input in the form of contact closures for each binary number in range from 2^0 to 2^{13}. Maximum conversion time 1 sec. Scale factor control enables operator to multiply decimal conversion by a constant.—*Electro Instruments, 3796 Rosecrans St., San Diego 10, Calif.*

BINARY DECIMAL CONVERTER
4365

For more information circle **255** on inquiry card.

NUCLEONICS

Uranium Detector

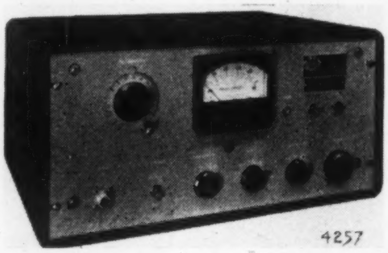
New "Mark II Uranium Tester" utilizes ultraviolet radiation of normal sunlight; enables prospector or lab technician to positively identify uranium in samples. (More than thirty radioactive minerals do not contain uranium.) —*Menlo Research Lab., Menlo Park, Calif.*

Lens transmits L-W U-V, absorbs 98% of visible sunlight radiation
URANIUM TESTER
TESTER
4227

For more information circle **256** on inquiry card.

Intensity Indicator

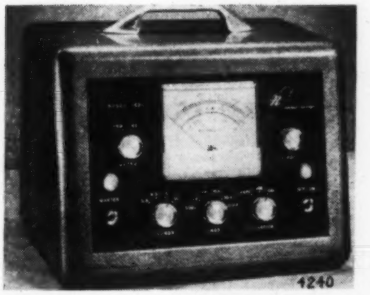
New "Oak Ridge Linear Count Rate Meter" said to contain "probably the most advanced circuitry for equipment of this type," designed by ORNL staff of electronic engineers, is built under contract, is now available to general public; has provision for driving a recorder.—*Radiation Counter Labs., Inc., 5122 W. Grove St., Skokie, Ill.*



For more information circle **257** on inquiry card.

Count Rate Meter

New "Model 1620 Analytical Count Rate Meter" converts random counts from Geiger or scintillation detector into average counting rate and pre-



4240

sents this average on 4-in. indicator calibrated in counts per minute. Six ranges up to 100,000 cpm.; individual calibration controls for each range; master calibration control compensates for small shifts. If desired, "1620" may be connected directly to a chart recorder.—*Nuclear Instrument and Chemical Corp.*, 229 *W. Erie St., Chicago* 10, *Ill.*

For more information circle **258** on inquiry card.

Geiger Counter

4228

New "Mark IV" of maker's Geiger counter incorporates more than twenty improvements: printed wiring for weight and bulk reduction; radioactivity indicated visibly on a microammeter calibrated in mr/hr., by a flashing red neon lamp and by audible signals through earphones. Full scale sensitivity of 0.2 mr/hr. may be reduced by 1/10th and 1/100th—*Menlo Research Lab., Menlo Park, Calif.*

For more information circle **259** on inquiry card.

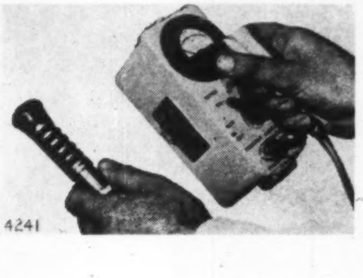
Prospecting Counter

New "Model GC 235 Prospectometer," is a Geiger counter specifically designed for uranium and thorium prospecting weighs 5½ lbs.; features watertight directional probe with shield for beta-gamma discrimination; signals radioactivity in three ways: earphone clicks, pointer-and-scale indication, and flashing neon light. Three ranges: 0.2, 2 and 20 mr/hr. Calibration chart and calibrating standard.—*The Radiac Co., Inc.*, 489 *Fifth Ave., New York* 17, *N. Y.*

For more information circle **260** on inquiry card.

Small Survey Meter

New "Model GS-3 CD" civil defense survey meter exceeds CVD-700 specs., is said to be smaller in size, lighter in weight, and more rugged than any similar meter now available; detects

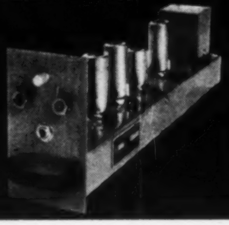


4241

THE FACTS ABOUT

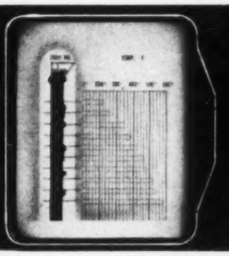
KYBERNETES

"High Speed Scanning Systems"*

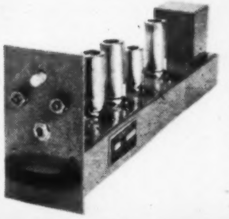


60 times per second is the sampling rate of **each individual transmitter.** As many as 40 transmitters may be used per unit system utilizing a single co-axial cable for transmission. Inputs available for thermistors, thermocouples, strain elements, and transducers for all process variables.

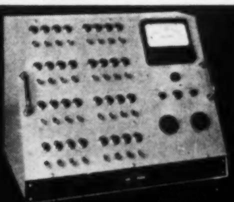
2400 bits of information per second (60 x 40) may be transmitted by a **single co-axial cable** to the receiving area.



Dynamic Visual Display of all variables on one or more kinescopes directly connected to the co-axial cable. In multiple gauging installations, all points can either be displayed relatively against the normal operating level, or in absolute units. This opens new areas in the field of dynamic analysis, i.e. component frequency amplitudes may be simultaneously displayed in vibration analysis. Scope does not interfere with receiver operation.



Receiver unscrambles 2400 bits of information per second into continuous signal outputs for each measured variable. Output signals are compatible for use with conventional indicating and recording instruments. Also digitized print-out, data storage, and computing systems.



Scanning operation is never interrupted. Annunciator system is fail-safe and is provided with individually adjustable alarm points, each with its own alarm lamp. Indicator permits read-out of any point under alarm or normal conditions.

All types of indicating, recording, print-out data storage and computing instruments and systems.

Additional Features: Fail-safe operation — high degree of linearity and stabilization against component drifts and tube aging — insensitivity to line voltage fluctuations. Unitized plug in construction for flexibility — readily JANized for airborne and military applications.

For specific information applicable to your own monitoring requirements, write today.

THE KYBERNETES CORPORATION
DIVISION OF SELF WINDING CLOCK CO., INC.
[illegible] EAST 40TH STREET, NEW YORK 16, NEW YORK (*Patent Pending) ©1954

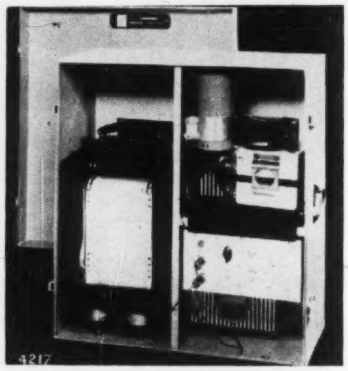
For more information circle **52** on inquiry card.

beta and gamma radiation; has three ranges: 0-0.5/5/50 mr./hr.; weighs 4¾ lbs. complete with headphone and carrying strap.—*Nuclear Measurements Corp., 2460 Arlington Ave., Indianapolis 18, Ind.*

For more information circle **261** on inquiry card.

Gamma Recorder

New "PRAM-5" recording gamma radiation monitor operates on dry cells unattended for 200-hour periods. Recorder has spring motor; built-in alarm warns personnel; splash-proof cabinet is easily decontaminated. Range 0.1 mr/hr. to 100 r/hr. (up to 500,000 r/hr. available).—*Jordan Electronic Mfg. Co., Inc., 119 E. Union St., Pasadena 1, Calif.*



For more information circle **262** on inquiry card.

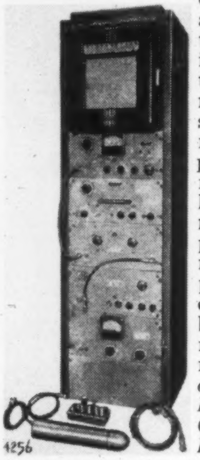
Scintillation Detector

New "Models 810 and 810A" bench model lead-shielded well-type scintillation detectors are available for analysis of gamma-emitting radioisotopes; can be used with a pulse height analyzer to form a spectrometer, or with scalers for sample counting. Emissions from single or mixed sources can be counted.—*Atomic Instrument Co., 84 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **263** on inquiry card.

Pulse-height Analyzer for gamma-ray Spectra

New "Mark 20 Model 1 Recording Spectrogammeometer" is for rapid identification of nuclides by their qualitative spectra and for quantitative analysis of isotopic concentrations. Main components: shielded scintillation probe, regulated negative-power supply, wide-range preamplifier, linear count-rate meter, scaler for precision determination of check points, *X-Y* recorder of relationship between counting rate and gamma ray energy.—*Radiation Counter Labs., Inc., 5122 W. Grove St., Skokie, Ill.*



For more information circle **264** on inquiry card.

Multiple-tube Counter

New "Nucliometer," for radioactivity detection where extreme sensitivity is required, can be had with either 24 standard beta-gamma-sensitive Geiger tubes or with bismuth-coated-cathode Geiger tubes two to five times more sensitive to radiation than standard Geiger tubes. Announcement states that although a scintillation counter is more sensitive per unit area than a Geiger Counter, "Nucliometer is superior for broad area surveying, especially from the air. Among features: compensator for the variations of background counts in different areas; selection of time-constants from 2 to 16 seconds.—*The Radiac Company, Inc., 489 Fifth Ave., New York 17, N. Y.*

For more information circle **265** on inquiry card.

OPTICS

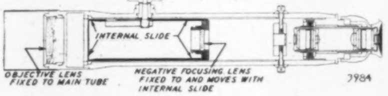
Germanium Infrared Filter

New "Germanium Infrared Transmission Filter," first optical filter made from germanium, is 1⅛ in. in diameter and ⅛ in. thick; ground, polished and coated on both sides; anti-reflection coated for maximum transmission at 2.5 microns; absorbs wavelengths shorter than 1.8 microns and transmits both near and far infrared regions; is well suited for use with lead sulfide detectors.—*Baird Associates, Inc., 33 University Rd., Cambridge 38, Mass.*

For more information circle **266** on inquiry card.

Transits and Alidades

New models of maker's transits and alidades include features of internal focusing which, in combination with variable power eyepiece now standard on maker's transits, makes possible a greater range of magnification than was possible with external focusing-type instruments. New alidades will have a much larger objective lens than before, and will allow more light in instrument. Maker's "Telescopic Solar Transit" will be available with either internal or external focus.—*W. & L. E. Gurley, Troy, N. Y.*


INTERNAL SLIDE
OBJECTIVE LENS FIXED TO MAIN TUBE
NEGATIVE FOCUSING LENS FIXED TO AND MOVES WITH INTERNAL SLIDE
7984

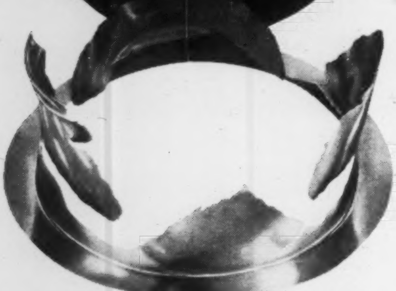
For more information circle **267** on inquiry card.

Surveyor's Transit

New 3-in. transit has full compass, horizontal and vertical 360-deg. cir-

Instant Automatic Release of

Excess Pressure



Rupture Discs

The safety of your pressurized equipment and your personnel depends upon the precision and accuracy of your rupture discs. Baker's long experience in the handling and fabrication of metals to minute tolerances is your best assurance of a product that will perform to specifications. Baker rupture discs are available in base metals, and in corrosion-resistant precious metals. They are made to your order for pressures up to thousands of pounds.

Send for the free booklet, "Baker Rupture Discs." Information and data to help you select the type of disc that will give you absolute protection.

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BAKER & COMPANY, INC. PRECIOUS METALS

113 ASTOR STREET, NEWARK 5, N. J.
NEW YORK • CHICAGO
SAN FRANCISCO • LOS ANGELES

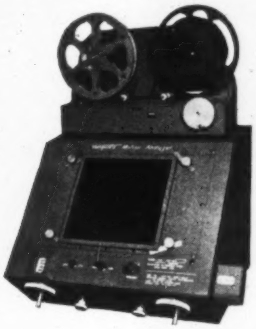
For more information circle **53** on inquiry card.

cle, 16X telescope; is complete with tripod case and accessories. Instrument weighs less than 6 lbs.; can be used to accuracy of 1 minute.—*Path Instruments, Inc.*, 16 *Hudson St., New York* 13, *N. Y.*

For more information circle **268** on inquiry card.

M-p. Analyzer

New "Vanguard Motion Analyzer" is a specialized projector for quantitative analysis of high-speed motion pictures, also of oscilloscopic recordings, etc., to obtain velocities, accelerations, deflections, stresses, etc.—*Photographic Analysis Co.*, 100 *Rock Hill Rd., Clifton, N. J.*



For more information circle **269** on inquiry card.

Photo Processor

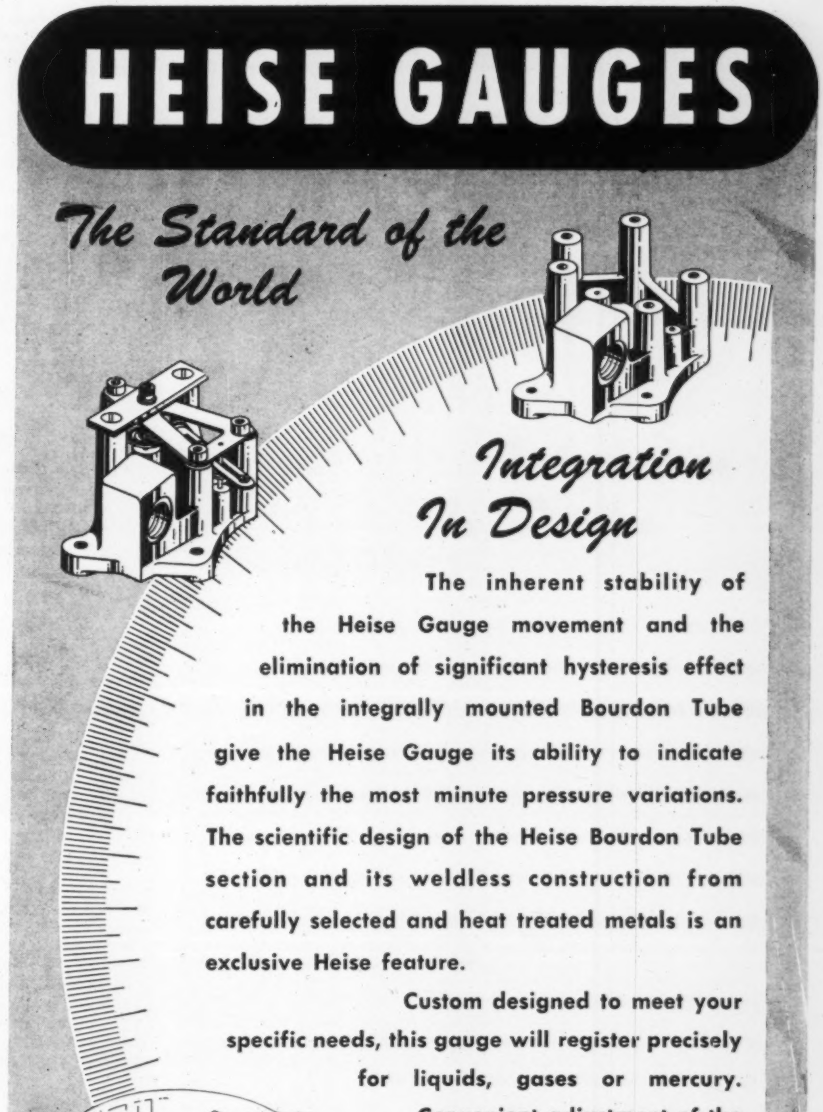
New "Processal" is a low-cost universal portable photographic film and paper processing unit. Accepts all conventional sizes of roll films and papers up to 12 in. wide; automatically develops, fixes and dries. Various models available for electrocardiograph papers, oscillograph papers and films, etc.—*Oscar Fisher Co., Inc.*, 1000 *N. Division St., Peekskill, N. Y.*

For more information circle **270** on inquiry card.

Miniature Lamp

New miniature lamp to be used for on-off indication on "hot" appliances comprises a small glass bubble sealed around a coiled filament, with two rigid pins protruding at base; will stand temperatures 30 percent higher than conventional miniature lamps (1060 abs. F. versus 810 abs. F.) therefore is expected to find wide use on irons, etc., where indicator lamps have been impractical.—*General Electric Co., Nela Park, Cleveland* 12, *Ohio.*

For more information circle **271** on inquiry card.


HEISE GAUGES

The Standard of the World

Integration In Design

The inherent stability of the Heise Gauge movement and the elimination of significant hysteresis effect in the integrally mounted Bourdon Tube give the Heise Gauge its ability to indicate faithfully the most minute pressure variations. The scientific design of the Heise Bourdon Tube section and its weldless construction from carefully selected and heat treated metals is an exclusive Heise feature.

Custom designed to meet your specific needs, this gauge will register precisely for liquids, gases or mercury. Convenient adjustment of the dial may be used to compensate for barometric changes.

Pressure Ranges
15 to 20,000 P.S.I.
DIAL SIZES
8½" – 12" – 16"
PRICES
from $151.60
DELIVERY
within 30 days

Catalog on Request

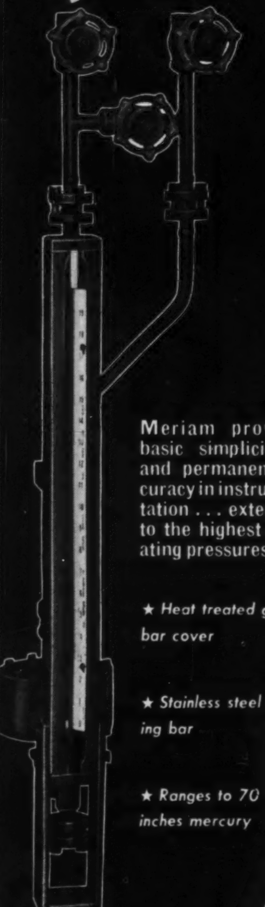
HEISE BOURDON TUBE COMPANY, INC.
BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **54** on inquiry card.

UNMATCHED ACCURACY

at highest working pressures

At pressures up to 2000 psi, this Meriam Manometer provides critically accurate flow or differential pressure measurement. Constructed of solid bar stock steel, all parts are precision fitted, hand lapped. Each unit is cold hydraulic tested to 5000 psi.



Meriam provides basic simplicity... and permanent accuracy in instrumentation... extending to the highest operating pressures.

★ Heat treated glass bar cover

★ Stainless steel backing bar

★ Ranges to 70 inches mercury

Write for Bulletin C-12.

Meriam Manometer Instrumentation ...for pressures, vacuums, flows, liquid levels.

meriam

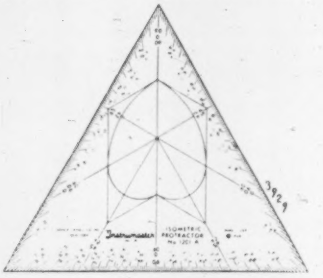
INSTRUMENT COMPANY

10920 Madison Ave. • Cleveland 2, Ohio

For more information circle **55** on inquiry card.

Isometric Protractor

New "No. 1201A" is added to "Instrumaster" line of Axonometric drawing equipment (isometric and dimetric). Either half may be used for any one of the three isometric planes. Correct orientation is automatically obtained. Two sets of numerals: figures read directly, which ever side is placed on drawing.—*John R. Cassell Co. Inc., 110 W. 42nd St., New York 36, N. Y.*



For more information circle **272** on inquiry card.

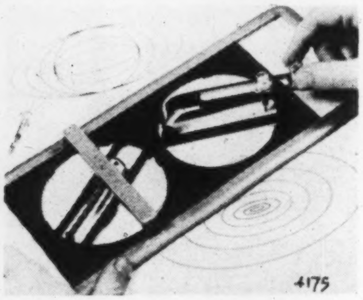
Surveyor's Level

New "Tilting Level" allows user to observe staff scale and coincident images of bubble on spirit level in telescope, at the same time; incorporates a new-style rough-and-fine movement tilting micrometer screw, and an easy-reading horizontal circle.—*Path Instruments, Inc., 16 Hudson St., New York 13, N. Y.*

For more information circle **273** on inquiry card.

Ellipsograph

New "Model A-140" is said to "draw consistently perfect ellipses of any desired size and degree." No computations necessary; self-calculating charts are provided for every possible ellipse situation, "even for isometric ellipses." —*Fowler Engineering, 1109 Maple St., Whittier 2, Calif.*



For more information circle **274** on inquiry card.

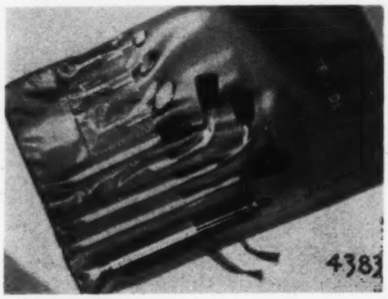
TV Camera

New "Tel-Eye" is a TV "station" the size of a cigar box, which sends clear, sharp, closed-circuit TV pictures by cable to screens of standard TV receivers, has been completely redesigned so that it provides greatly improved performance yet is much smaller and lighter (8¼ lbs.) than previous models.—*Allen B. Du Mont Laboratories, Inc., Clifton, N. J.*

For more information circle **275** on inquiry card.

Illumination Kit

New "Syte-Ayde" enhances accuracy of production and inspection procedures, and speeds work, by directing light in out-of-the way places. Powered by flashlight batteries, "Syte-Ayde" provides four light-transmitting rods: two straight (3½ and 6 in. long) and two of the same lengths are bent 90 deg.; three 1½ power mirrors, ½, ¾, and 1¼ in. diam., with clips which fit rod ends. All parts are contained in separate compartments of a plastic kit.—*General Scientific Equipment Co., 2700 W. Huntingdon St., Philadelphia 32, Pa.*



For more information circle **276** on inquiry card.

Lens Cleaner

New "Kleer Lens" squeeze-bottle lens cleaner is sprayed on and wiped off, produces clean sparkling finish with no harm to surface.—*General Cement Mfg. Co., 919 Taylor Ave., Rockford, Illinois.*

For more information circle **277** on inquiry card.

Gyro Sight Tester

New "Model 519 Gun-Bomb-Rocket Sight Tester" is designed to test gyro computing gun sights and to facilitate compilation of data to indicate operating characteristics of sight; features circuits for opening computer stiffness and sight head torque motor circuits; controlling displacement of target index; making characteristic time measurements; checking stiffness motor current, torque motor voltages; and checking excitation frequency and currents.—*Telectro Industries Corp., 35-18- 37th St., Long Island City 1, N. Y.*

For more information circle **278** on inquiry card.

LABORATORY

Electrophoresis Supplies

Two electronically regulated d-c. power supplies for use in electrophoresis have dual-range indicators for volts and milliamperes, high-voltage control knob, power switch, and high-voltage switch. "Model 1901" delivers 30 ma. in range between 160 and 400 v.dc., sufficient for operating several electrophoresis units simultaneously. "Model 1910" delivers 100 ma. between

THE 1956
INSTRUMENTS and AUTOMATION CATALOG and INDEX

—the industry's ONLY directory—

Publication date, July 1955

CIRCULATION: The *Index* will be sent to 20,000 users of instruments and devices for measurement, inspection, testing and control. These are the 20,000 most important men who buy, install and maintain instrument and control devices.

COMPLETE HORIZONTAL COVERAGE of the men who buy and specify instruments and controls in every major instrument-using company. The *Index* reaches the largest number of potential instrument buyers at lowest cost.

PRODUCTS ADVERTISED are scientific and industrial instruments; automatic electrical, mechanical, hydraulic, electronic and pneumatic controls; electric and electronic instruments; testing machines and devices; inspection devices and gages; control valves; relays; timers; laboratory and glass apparatus; etc.

CLOSING DATES: Copy to prepare, all details must be in our Pittsburgh Office not later than April 1st. Layout and copy will be sent to the advertiser for his OK and also final proofs.

Copy to set	May 20th
If no proof required	May 25th
Complete plates	June 1st
Inserts	June 15th

Advertisers' Names **Boldface** in Descriptive Directory: Advertisers in the *Index* will have their names in boldface type in the Descriptive Directory Section and reference will also be made to the page number (s) on which their advertisement (s) appear. This gives to the individual seeking information the two vitally important elements of the *Index*—1. Where he can buy it, and 2. Technical data, when he turns to the page to which he is referred.

RATES and Mechanical Requirements: Advertisers will be entitled to the rate earned in the 12 regular issues of *Instruments* and *Automation* or to the rate they earn in the *Index*, whichever is most advantageous. Space used in the *Index* will not help earn a rate in the regular issues of *Instruments* and *Automation*. But the rate earned in the regular issues will determine the rate for the *Index*.

INDEX RATES ARE THE SAME AS REGULAR *INSTRUMENTS & AUTOMATION* PER PAGE RATES

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2 Pages	354.00	8 Pages	302.00
3 Pages	344.00	9 Pages	297.00
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All AAAA Standard Colors: Red, blue, yellow, orange, green, $100.00 per page for any one color. Matched colors $120.00 per page for any one color. Rates for metallic inks quoted on request. Bleed Pages: per page, extra $75.00

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2 Pages (backed up)	$ 530.00
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	Width	Depth	Width	Depth
1 Page	7	10	—	—
⅔ Page	4½	10	—	—
½ Page	3⅓	10	7	4⅚
⅓ Page	2⅙	10	4½	4⅚
¼ Page	3⅓	4⅚	—	—
⅙ Page	2⅙	4⅚	—	—

Halftones should be 110 screen.
Page trim size—8¼" wide x 11¼" deep
Bleed size—8⅜" wide x 11½" deep
Actual type measurement inside border.

INSERTS (Letterpress): Rates for complete inserts apply on inserts which are ready for binding when received. Before making plates or ordering printing please check with the Pittsburgh Office as to number of pages, quantity required, trim size. Maximum acceptable weight 100 lb. coated, 25 by 38 inch basis, or equivalent.

REPRINTS: Regular run of book stock will be used unless special stock is supplied by the advertiser. For reprint costs write Pittsburgh Office.

INSTRUMENTS PUBLISHING COMPANY

845 Ridge Ave., Pittsburgh 12, Pa. **Telephone: Fairfax 1-0161**

See Page 491 For District Offices and Managers

For more information circle **56** on inquiry card.

Genisco's New GOH Accelerometer

withstands vibrational accelerations of 15 G's up to 2000 cps

Genisco
Genisco

PHYSICAL DIMENSIONS

OVERALL HEIGHT	3¼"
OVERALL WIDTH	3¼"
OVERALL DEPTH	3¾"
WEIGHT	38 OUNCES

Hermetically sealed

This newest Genisco Accelerometer is a rugged, oiled-damped, potentiometer-type instrument designed to operate in the most severe missile and aircraft vibrational environment. For example, in a recent production test the GOH performed satisfactorily after vibrational environment of 15 G's up to 2000 cps. As further proof of its ruggedness, the GOH will withstand 40-G shocks of 5 millisecond duration on the sensitive axis, and steady-state accelerations of 30 G's on the non-sensitive axes and 10 G's on the sensitive axis without damage.

HEATING ELEMENT AVAILABLE—A thermostat-controlled, internal heater may be installed in the GOH to keep operating characteristics constant between −50° F. and +160° F. However, thermostat operation is limited to 60,000 feet or less, 95% relative humidity at 160° F., and a vibrational environment of 10 G's up to 500 cps.

SPECIFICATIONS

Ranges: ±1 G to ±3 G's inclusive.
Natural Frequencies: 7 cps to 12 cps.
Nominal Damping: 0.65 of critical at 75° F. Values between 0.4 to 1 set if desired.
Resistance: 14000 ohms (±5%); center tap at 0 G-point. Other resistances also supplied.
Potentiometer Voltage: Up to 60 volts.
Resolution: One part in 300 for standard potentiometer.
Noise Levels: Less than 10 mv at 0.1 ma brush contact.
Linearity: Within 1% of full scale from best straight line through calibration points.

Complete technical data on the GOH and other Genisco Accelerometers and Pressure Transducers is available from Genisco, Incorporated, 2233 Federal Avenue, Los Angeles 64, California. Write for your copy today.

RELIABILITY FIRST

Genisco INCORPORATED

For more information circle **57** on inquiry card.

50 and 400 v.dc. and 30 ma. up to 600 v.dc. for simultaneous operation of up to 10 electrophoresis units.—*Research Specialties Co., 1148 Walnut St., Berkeley 7, Calif.*

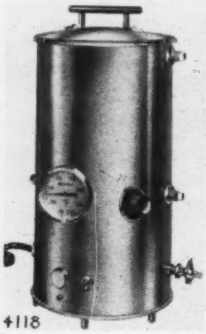
For more information circle **279** on inquiry card.

Water Demineralizer

New "Model DM-1," for use in industrial and school laboratories, features completely automatic operation. Storage tank holds 4 gal. of treated water ready for use; faucet rate 1 gal./min.; no waiting: tank refills and shuts off during periods between use; unique split column design permits all of resin to be used without waste yet maintains maximum purity at approx. 6 megohms/cm^2. —*Scientific Equipment Corp., 5438 Lowell Ave., Indianapolis, Ind.*

For more information circle **280** on inquiry card.

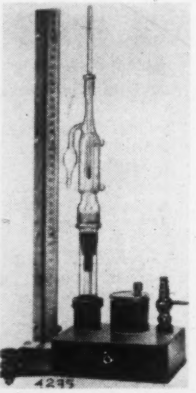
Distilled Water Heater



New 1½-gal. 650-watt heater keeps hot distilled water on tap for instant use at any predetermined temperature by means of an adjustable thermostat; available for 110 or 220 volts.—*Barnstead Still & Sterilizer Co., 244 Lanesville Terrace, Forest Hills, Boston 31, Mass.*

For more information circle **281** on inquiry card.

Surface Tensiometer

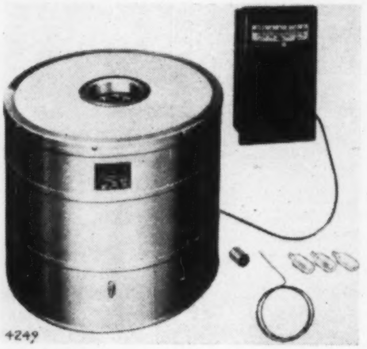


New "Model T-30" measures surface tension of liquids over a wide temperature range, uses extremely minute (0.02ml.) sample. Closed chamber construction permits surface tension to be measured in any desired gas. Principle: measuring maximum pressure attainable inside a small bubble (formed over an orifice: no corrections for hydrostatic head of liquid.)—*National Instrument Laboratories, Inc., 6108 Rhode Island Ave., Riverdale, Md.*

For more information circle **282** on inquiry card.

Carbon Residue Apparatus

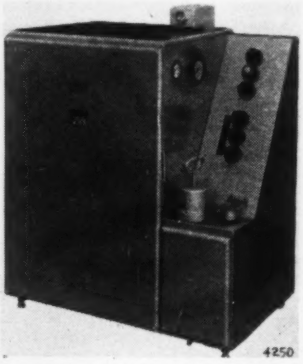
Newly redesigned "Ramsbottom Carbon Residue Apparatus" conforms to latest ASTM D 524. Test temperature now can be held to within 5 F. —*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*



For more information circle **283** on inquiry card.

Flash-point Tester

New "Automatic Loading Rack Flash Point Tester" checks flash points of distillate fuel shipments in delivery or at terminals, tanker wharves, etc.; can be operated by truck driver or loader; correlates with ASTM D 56 but does not require lab installation or skilled operator.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*



For more information circle **284** on inquiry card.

High-capacity Chlorinator

New improved model of high-capacity solution feed type chlorinator has six metering tube and float combinations (interchangeable) to provide 10-to-1 or greater overlapping flow ranges from 100 to 8,000 pounds per day of chlorine gas. In addition to manual chlorine flow-rate adjustment, available automatic functions: (1) Automatic proportioning by pneumatic signal from flowmeter; (2) automatic proportioning by link to a float in a flume, weir or tank; (3) remote pneumatic set; (4) program controlled operation; (5) timer sequence control; (6) automatic pump sequence control; (7) automatic start-stop control.—*Fischer & Porter Co., 296 Jacksonville Rd., Hatboro, Penna.*

For more information circle **285** on inquiry card.

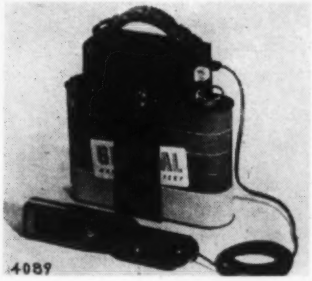
Molecular Filter

New biochemical molecular filter has openings approaching atomic dimensions, can be used to separate large molecules from small ones (can separate hemoglobin molecules from salt molecules present in plasma).—*The Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y.*

For more information circle **286** on inquiry card.

Ultraviolet Source

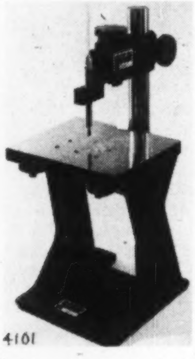
New improved "Mineralight" comprises a "Model SL 3660" long-wave "Mineralight" for a-c. operation, and a 6-volt adapter for use with a portable "hot shot" battery or other 6-v. source.—*Ultra-Violet Products, Inc., 145 Pasadena Ave., South Pasadena, Calif.*



For more information circle **287** on inquiry card.

TESTING, INSPECTION

Bench Comparator

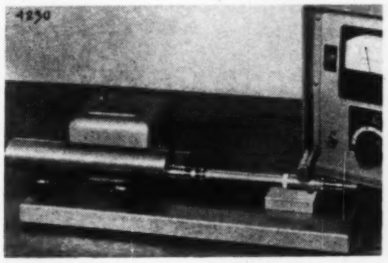


New "STD-5" is for measurements utilizing any AGD design mechanical indicator or air-probe type of gaging equipment; features system of superfine adjustment with 0.040 range. Column can be mounted under platen.—*Acra-ment Gage Div., Myer Corp., Park Ave., Cranston, R. I.*

For more information circle **288** on inquiry card.

Cylindrical Surface Roughness Pickup

New "Type RF Cylinder Pilotor" is for taking "Profilometer" roughness measurements around outside or in-



Circle **58** on inquiry card. →

PANALARM "50"

OPENS THE DOOR

TO MORE DEPENDABLE ANNUNCIATOR PERFORMANCE

WITH NEW "INSTRUMENT-TYPE" CONSTRUCTION

LOOK inside the new Universal PANALARM "50". You will realize that here, at last, is an annunciator system built for *long term* dependability and service. Built to match the responsibility an annunciator must assume in your plant.

The PANALARM "50" Cabinet has a substantial hinged door . . . with sub-door to allow easy access to signal lamps. It has a new, rugged chassis design . . . pre-wired to handle any standard audio-visual signal requirement . . . and so flexible that signal sequences can be changed by simple terminal connections. No re-wiring is needed.

All moving parts and contacts of the PANALARM "50" are within hermetically sealed, plug-in units. They are corrosion-proof and suitable for Class I, Div. 2 locations. All connections are made to a single terminal block . . . with ample space for wiring.

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PANALARM

PANALARM PRODUCTS, INC.
7405 N. Hamlin Ave., Skokie, Illinois

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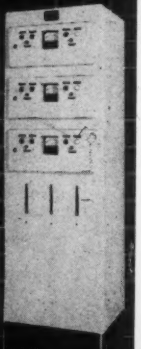

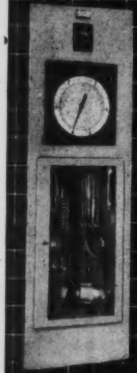

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operating by catalytic combustion, electro-conductivity, thermal conductivity, and photochemical reactions.

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For the analysis of gases and vapors that ionize in water, directly or when decomposed by heat. Sensitive to small quantities.
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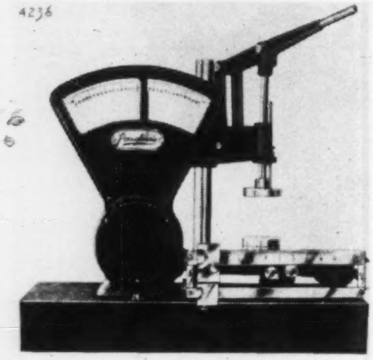
80 Halleck St., Newark 4, N. J.
Progressive Manufacturers of
Gas Analysis Instruments
For more information circle 59 on inquiry card.

side circumference of solid or hollow cylindrical pieces. Roughness measurement is made by a "Type LA Tracer," supported by a "Linkarm" and remaining stationary while workpiece rotates.—*Micrometrical Mfg. Co., 345 S. Main St., Ann Arbor, Mich.*

For more information circle **289** on inquiry card.

Spring Testers

New "Type 4000" (15-lb.) and "Type 5000" (50-lb.) rapidly test tension, compression or leaf springs; are also recommended for checking force required to engage or disengage mating sub-assemblies and components. —*Pennsylvania Scale Co., Bareville, Penna.*



For more information circle **290** on inquiry card.

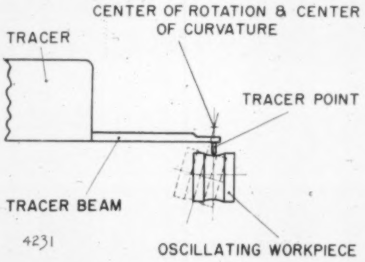
Small-parts Inspector

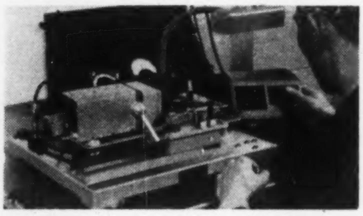
New "Model 144 B-53" semi-automatic sorting gage measures small curved parts and sorts them into six good categories, plus oversize and undersize, at rate of approx. 2,500 pieces an hour, depending upon dexterity of operator.—*Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

For more information circle **291** on inquiry card.

Ball-bearing Raceways Roughness Pickup

New race-groove "Pilotor" accommodates inner and outer races of bearings from 5/16 in. to 1 in. O.D. Workpiece is held in an adapter on a horizontal spindle that reverses automatically at ends of desired arc trace. —*Micrometrical Development Corp., 2821 S. State St., Ann Arbor, Mich.*





For more information circle **292** on inquiry card.

Surface-finish Pickups

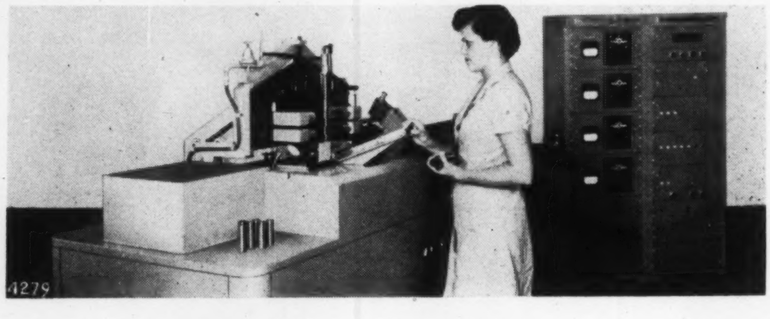
Six new accessories adapt "Surfindicator" for special applications; provide (with general-purpose "Pickup Model BL-111" plus "Motor Drive Model BL-114") methods of measuring surface roughness to include nearly every purpose related to this field. (1) small bore adapter "Model BL-113," (2) chisel stylus adapter "Model BL-130," (3) minimum clearance adapter "Model BL-131," (4) hole bottom adapter "Model BL-132," (5) rough finish adapter "Model BL-133," (6) hand-held small bore adapter "Model BL-134."—*Brush Electronics Co., 3405 Perkins Ave., Cleveland 14, Ohio.*

For more information circle **293** on inquiry card.

Automatic Inspector and Classifier for Piston Pins

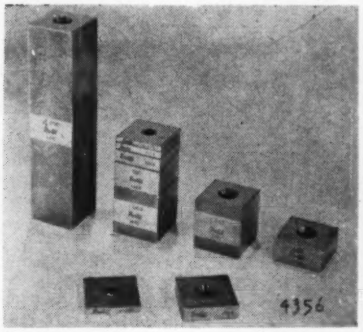
New "Model 144 B-32 Electronic Sorting Gage" measures hardness, length, out-of-roundness, OD, and taper of automotive piston pins; sorts them at rate of 4000 per hour.—*Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

For more information circle **294** on inquiry card.



Square Gage Blocks

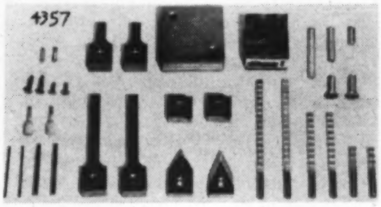
New square gage blocks supplement maker's line of rectangular blocks and gaging equipment; feature exceptionally fine finish for easy wringability and long life.—*The DoALL Co., Des Plaines, Illinois.*



For more information circle **295** on inquiry card.

Gage-block Accessories

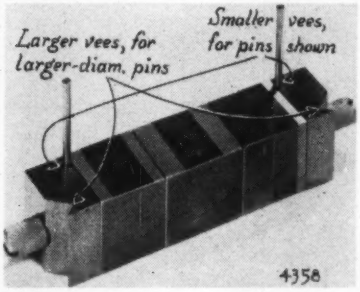
New accessories have been developed especially for use with all of maker's new standard square gage blocks; permit great flexibility in constructing everyday working gages from these new blocks; include all necessary parts for fastening blocks together as well as special gaging members and bases for constructing gages for specific applications.—*The DoALL Co., Des Plaines, Illinois.*



For more information circle **296** on inquiry card.

Standard-block Gages

New caliper gages (illustrated) and indicating gages, all of highest precision, for inside (illustrated) and outside dimensions, are constructed from maker's new standard square gage blocks and special new parts.—*The DoALL Co., Des Plaines, Illinois.*


Larger vees, for larger-diam. pins
Smaller vees, for pins shown
4358

For more information circle **297** on inquiry card.

Dial Caliper

New "Dial-Cal" is said to be "the first and only caliper to replace vernier scales with a direct-reading dial, permitting instant calibration to thousandths of an inch." It can measure ID, OD, knife-edge (for recesses), and

HOW CHACE THERMOSTATIC BIMETAL ACTUATES THE BAKE-WELL OVEN THERMOMETER

OVEN THERMOMETER

Product of the Cooper Thermometer Co., Pequabuck, Connecticut

In the twenty years the Bake-Well Portable Oven Thermometer has been manufactured, its efficient performance and low cost have established its popularity in millions of homes in this country and abroad. Although most cooking appliances and stoves are now made with integral automatic controls, the housewife still regards an on-the-spot heat indicator as more accurate.

A coil of Chace Thermostatic Bimetal furnishes the thermally responsive element which actuates this simple device. One end of the coil is anchored to the frame of the thermometer. The other end of the coil is fastened to a pointer. Temperatures in excess of 100°F. cause the bimetal coil to expand, rotating the pointer to register the correct temperature on dial. The Chace Thermostatic Bimetal coil is accurately calibrated at the factory to insure positive temperature indication over many years of dependable service.

Chace Thermostatic Bimetal is available in 29 different types, in strip, coils or in completely fabricated assemblies made to customer specifications. Send now for our new, free 36-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing valuable engineering information for designers of thermally responsive devices.

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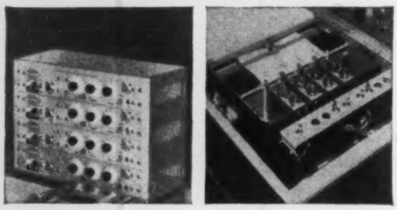
Simplifies Your Instrumentation with this NEW *Expandable* Consolette Recorder

Start with a 2 Channel System



Add units, as you need them, to make a 4, 6 or 8 Channel System.

The Consolette gives you rack mounted dimensions with option of Direct Coupled, Condenser Coupled or Carrier Amplifiers; a wide variety of chart speeds and galvanometer types; full writing desk for review of intelligence; and an efficient, modern and beautifully designed instrument.

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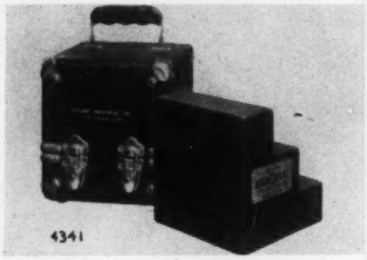
For more information circle **61** on inquiry card.

depth. Six-inch capacity.—*Precision Tool Sales*, 417 *East Florence Ave., Los Angeles* 3, *Calif.*

For more information circle **298** on inquiry card.

Granite Angle Plate

New black granite angle plate, for use with "Microflat" granite surface plates and layout plates, facilitates clamping of tools and fixtures; can be used for inspection or assembly applications.—*Collins Microflat Co.*, 2326 *E. 8th St., Los Angeles* 21, *Calif.*



For more information circle **299** on inquiry card.

Motor Tester

New "Incremental Motor Test Unit" tests 8 stepping or incremental motors at a time, for any desired duration, at 10 or 15 pulses per second. If any motor misses one pulse or step, this fault is continuously displayed on "Failure Indicator" though motor continues to operate. "Phase Indicator" is used for initial phasing and also indicates that motor is operating.—*Cal-Tronics Corp.*, 11307 *Hindry Ave., Los Angeles* 45, *Calif.*

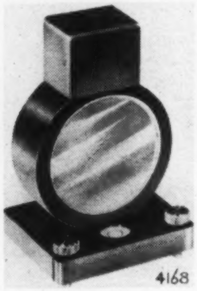
For more information circle **300** on inquiry card.

Vibration Tester

New "68" electrodynamic shaker system for vibration-testing assemblies and components can develop 100 lbs. peak force output in 40 to 3000 cps. frequency range, and displacement amplitudes in excess of 0.4 in. peak-to-peak in 5 to 40 cps. range. New flexure system insures truly linear motion of armature. New built-in calibrated velocity signal generator monitors amplitude.—*The Calidyne Co.*, 120 *Cross St., Winchester, Mass.*

For more information circle **301** on inquiry card.

Leveling Mirror



New Vertical Leveling Mirror, for use in optical tooling, has mirror automatically positioned in a vertical plane and mounted on a base provided with leveling screws; is insensitive to air currents, temperature changes, static field, magnetism, etc. Auto-reflection and autocollimation available from either side of mirror assembly.—*Farrand Optical Co., Inc., Bronx Blvd., & E. 238th St., New York* 70, *N. Y.*

For more information circle **302** on inquiry card.

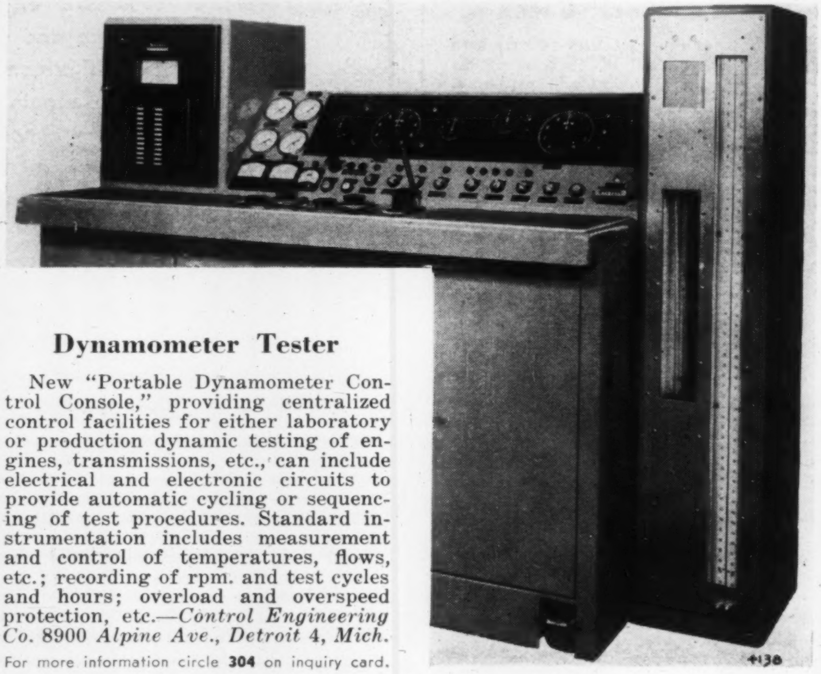
Snubber-type Grips

New snubber type grips for tensile strength tests of wire up to 0.06 in. diam. are designed to minimize or prevent breaks at grips and thus permit breaks to occur within free length of wire specimens.—*Baldwin-Lima-Hamilton Corporation, Philadelphia* 42, *Pa.*

For more information circle **303** on inquiry card.

Salt Spray Chamber

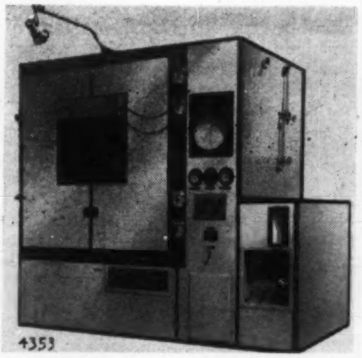
New salt spray (fog) test chamber, interior dimensions of 48 x 48 x 48 in., meets QQM-151-a, MIL-1572, etc.



Dynamometer Tester

New "Portable Dynamometer Control Console," providing centralized control facilities for either laboratory or production dynamic testing of engines, transmissions, etc., can include electrical and electronic circuits to provide automatic cycling or sequencing of test procedures. Standard instrumentation includes measurement and control of temperatures, flows, etc.; recording of rpm. and test cycles and hours; overload and overspeed protection, etc.—*Control Engineering Co.* 8900 *Alpine Ave., Detroit* 4, *Mich.*

For more information circle **304** on inquiry card.

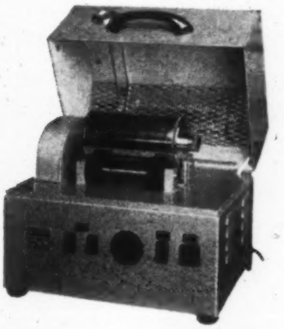


Main chamber is water-jacketed; chamber temperature is controlled by thermostat in circulating water line; spray air is warmed and humidified by bubbling-tower; salt solution reservoir provides for more than 60 hours. Various instrumentation extras are available.—*Development Engineering Co., 9 Cross St., Norwalk, Conn.*

For more information circle **305** on inquiry card.

Roll Grease Tester

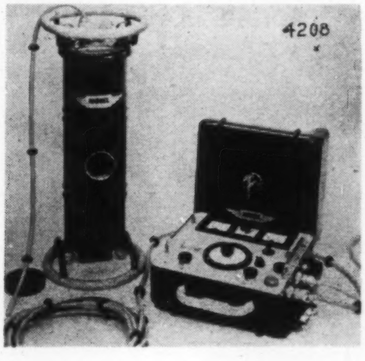
Newly redesigned "Roll Tester for Greases" provides many new features in order to conform with both Shell Rolling Stability Test and Amendment 2, MIL-G-10924 (ORD). Among new features: temperature control from room to 175 F. with accuracy of approx. 1 F.; speeds of 10 and 160 rpm.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*



For more information circle **306** on inquiry card.

Industrial X-ray Unit

New 160 kvp portable x-ray unit for industrial radiography can x-ray 2 in. of steel; comprises a 120-lb tube unit and a 60-lb. control unit; operates on 110 and 220 v. independent of separate transformers. Focal spot in rugged x-ray tube is 1.5 mm., insuring



NEW

Arnold O. Beckman

MODEL F3

OXYGEN ANALYZER

with the meter on the door

New convenience has been built into the well-known F3 Oxygen Analyzer . . . a meter on the door provides readings at the sampling point for making calibration checks, process changes, etc. In fact, complete analyzing, calibrating and indicating components are now incorporated into the single F3 unit—at no extra cost!

Use The Model F3

ON OPERATIONS LIKE THESE . . . TO MAKE SAVINGS LIKE THESE

COMBUSTION **Boilers, Kilns, Direct-Fired Heaters, Stills, etc.**	*Higher combustion efficiencies at lower fuel costs*
PROCESSING **Air Liquifraction . . . Processing Butadiene, Acetylene and Similar Gases**	*Better product quality with minimum oxygen or air contamination*
PLANT SAFETY **Hydrogenation, Hydrofining, Gas Compressors, Sulfur Grinding, etc.**	*Control explosive atmospheres, reduce fire risks, minimize plant and personnel hazards*

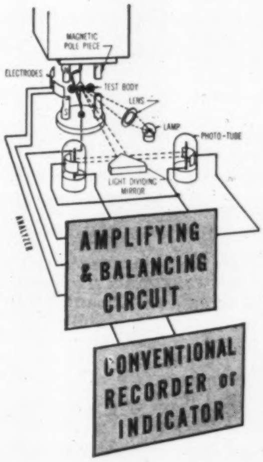
Unique Operating Principle

The various applications highlighted above are only a few of the many ways Arnold O. Beckman Oxygen Analyzers—industry's great new profit builders—are being used by progressive operators to boost profits, cut costs.

These are the *only* oxygen analyzers that *continuously* measure process streams by an advanced magnetic principle that provides *direct physical measurement of the oxygen itself*—not of some secondary relationship.

Heart of the unit, as illustrated, is a dumbbell-shaped test body suspended in a magnetic field. Sample gas surrounding this test body causes it to rotate in the field, depending upon the oxygen content of the gas. The movement of a light beam, reflected by a small mirror on the test body, is measured by simple electronic circuits . . . and the result indicated directly on a conventional recorder or indicator. It's simple, positive, accurate!

No chemicals—filaments—catalysts cams—complicated mechanical parts!



FEATURES OF THE F3

Many Ranges: Full scale ranges of 0-5%, 0-10%, 0-15% O_2 and higher.

Accuracy: 1% of full scale.

Multi-Ranges: Any instrument may be supplied with two or more ranges.

Note: For ranges narrower than 0-5% O_2 ask about the Model G2.

Send for Helpful Free Literature *which describes this unique operating principle in detail—explains its many advantages and applications. When writing, outline your particular operations—we'll gladly supply specific information.*

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Arnold O. Beckman INC.

Instruments for Science and Industry

1020 MISSION STREET
SOUTH PASADENA, CALIFORNIA

For more information circle **62** on inquiry card.

NEW and Proved
Precision Temperature Control for
greater sensitivity

with
HALLIKAINEN Resistotrol

Typical Thermometer Bulbs

For precision temperature control of baths, ovens, kilns, dryers and plastic extrusion presses, the Hallikainen Resistotrol has a sensitivity between "on and off" of 0.005 degrees F.

The Resistotrol operates on the principle that a change in temperature governs the resistance of a wire wound resistance type temperature bulb, which is one leg of an AC Wheatstone Bridge. This resistance change produces an unbalanced voltage across the bridge that is further amplified by a resistance coupled amplifier. This amplified voltage is used as bias voltage for a thyratron relay tube which operates an enclosed mercury switch controlling the heater power.

REPRESENTATIVES: Write us about territories still open. Give full details.

Color Alarm • Thermometer Calibration Baths • Hydrogen Analyzer • Radiological Gas Analyzer • Alkylation Acid Analyzer • and other analytical instruments for continuous processes.

HALLIKAINEN *Instruments*
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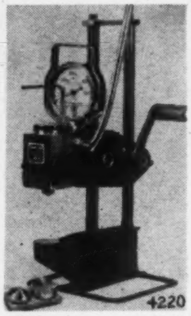
1341 Seventh Street, Berkeley, Calif.

For more information circle **63** on inquiry card.

sharp definition in radiographs.—*Holger Andreasen, Inc., 703 Market St., San Francisco 3, Calif.*

For more information circle **307** on inquiry card.

Portable Hardness Tester

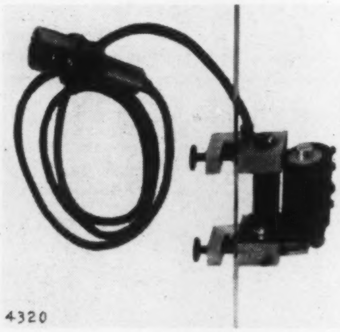


New lightweight (26-lb.) Brinell hardness tester features removable test head making it possible to test parts of any size or shape; can be used in any position, even upside down, with or without base. 1000-kg. maximum load; 5-mm. and 10-mm. balls. (Where a small impression is desirable, a 5-mm. ball with a 750-kg. load will cover same hardness range as a 10-mm. ball and 3000-kg. load.)—*Andrew King, 67 E. Lancaster Ave., Ardmore, Penna.*

For more information circle **308** on inquiry card.

Extensometer

New "Model P-101MS" non-averaging screw-on separable "Microformer" type extensometer is for use on ½-in. wide flat specimens 0.005 to 0.250 in. thick with 2-in. gage length.—*Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pa.*



For more information circle **309** on inquiry card.

Ultrasonic Analyzer

New Ultrasonic Attenuation Analyzer employs a transducer to beam a short ultrasonic signal through material being inspected, and obtains information from return pulses: (1) attenuation of signal, (2) its characteristic velocity and (3) shape of reflected pulses. This information, displayed on cathode-ray tube, instantly reveals discrepancies between workpiece and comparison standard.—*Vibro-Ceramics Corp., Metuchen, N. J.*

For more information circle **310** on inquiry card.

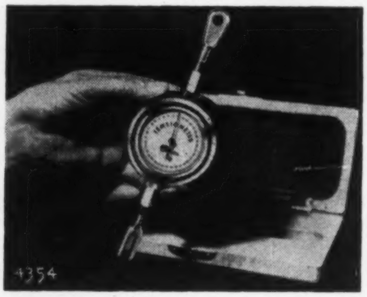
Gamma-ray Sets

New "Gamma Rays Machines" penetrate steel plate up to 8 in. thick; utilize radioactive isotopes to produce x-ray-type pictures of heavy industrial products; provide high degree of operator safety. "Model A" weighs 47 lbs., can be carried; "Models B and C" can be rolled on shop floors.—*Gamma Industries, Inc., P. O. Box 2271, Baton Rouge, La.*

For more information circle **311** on inquiry card.

300-lb. Proving Ring

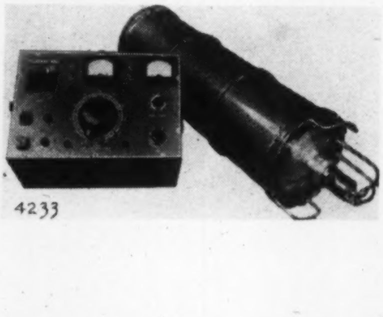
New proving ring is of entirely new turnbuckle type: In addition to reading tensile or compression loads, it can be employed to apply a tensile load by simply taking up on turnbuckle forks at opposite sides (desirable in many test set-ups whre there is no room for normal loading devices).—*W. C. Dillon & Co., Inc., P. O. Box 3008, Van Nuys, Calif.*



For more information circle **312** on inquiry card.

Mobile X-ray Unit

New "X-tron 180," for complete circumferential x-ray of weldments, etc., contains a transformer and x-ray tube and a high-voltage generator that delivers 180 kv. and 10 ma. continuously;



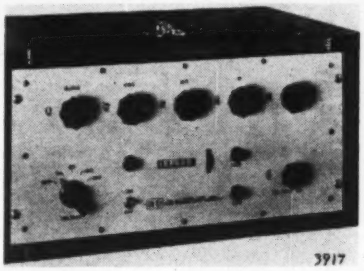
will penetrate 2⅛ in. of steel and a pipe line greater than 12 in. diam.; can be placed in center of a ring of castings so that they all can be x-rayed at one time. All parts are of American make and can easily be replaced.—*Mitchell Radiation Products Corp., 128 E. Washington St., Norristown, Pa.*

For more information circle **313** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Resistor-sorting Bridge

New "Type 32" can measure 7500 resistors per hour; "memory" retains reading until signalled that action has been taken. Range 1 ohm to 30 megohms. Six-digit counter can register either high or low units.—*Barnes Development Co., 213 W. Baltimore Pike, Landsdowne, Penna.*


3917

For more information circle **314** on inquiry card.

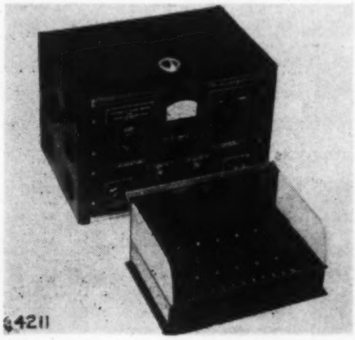
Watthour-meter-testing Photoelectric Equipment

New photoelectric equipment for testing watthour meters is available in portable and switchboard models, incorporates a smaller cadmium sulphide cell having higher sensitivity: 3/64 in. diam. and mounted on a 5/32-in. diam. tube. Using new meter tester for anti-creep hole method, sensitive cell and light source can be set from 3 to 4 feet apart, permitting many meters to be tested without adjusting cell and light source between tests.—*General Electric Co., 40 Federal St., West Lynn 3, Mass.*

For more information circle **315** on inquiry card.

Insulation Tester

New "Hi-Pot Model A" automatically tests, in sequence, dielectric strength between any ten conductors and indicates location of breakdown when it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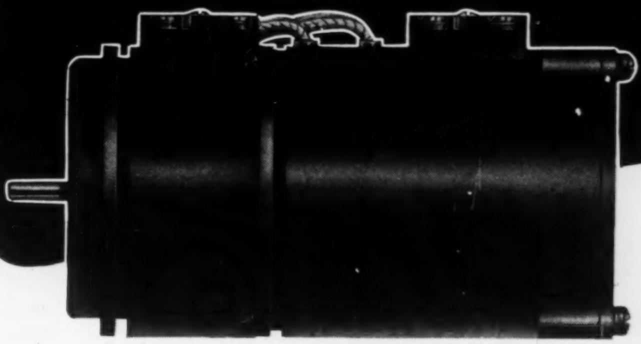
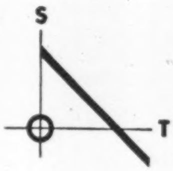
Tachometer Feedback

with Instrument Servo Motors



and now, a DIEHL Instrument Servo Motor and Integrally-Mounted Alternating Current Tachometer-Generator assures stability in a Servo loop. Designed for simple and easy mounting and can readily be adjusted after installation so that the in-phase residual voltage is essentially zero. A high impedance control-phase winding is available for plate to plate operation. 57½/57½ volt control-phase windings can be provided for magnetic amplifier applications. Diehl Motor-Tachometer combinations are obtainable with Gear Reducers in 5 different ratios. Attractively priced for commercial applications.



MOTOR RATINGS
1, 5 and 10 watts output
GEAR REDUCTION RATIOS
191.1 to 1
76.6 to 1
32.4 to 1
13.8 to 1
5.8 to 1

TACHOMETER SPECIFICATIONS	
Input (volts)	115
Frequency (cycles)	60
Output (volts per 1000 RPM)	5.5
Linearity	1%

Our engineering staff will gladly help you select the equipment best suited to your requirements. A request on your letterhead will bring you a copy of Technical Manual No. IN-455 describing Diehl Servo Motors and related equipment.

Other Available Components:
D.C. SERVO SETS • RESOLVERS
MINIATURE PERMANENT MAGNET D.C. MOTORS

Diehl

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING CO
Finderne Plant, SOMERVILLE, N. J.

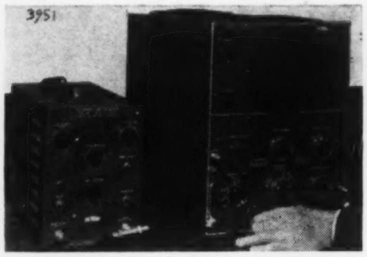
For more information circle **64** on inquiry card.

occurs. Test interval can be accurately controllable to 120 sec.; applied voltage continuously variable to 2000. Can be used for production testing of slip rings, commutators, cable connectors, synchros, etc.; can be supplied with more than ten test positions.—*Industrial Test Equipment Co., 55 E. 11th St., New York 3, N. Y.*

For more information circle **316** on inquiry card.

TV Package Laboratory

New inexpensive video-signal monitor, primarily for use in TV broadcasting, is made available by "packaging" maker's "Type 325 TV Line Selector" and "Type 327" CRO, both just developed. Line Selector is operated by three controls which enable operator to count down to any particular horizontal line, serrated or equalizing pulse of a composite TV signal, at which point it produces a synchronizing signal to trigger CRO and display signal from selected point. Any portion of composite video signal can thus be examined. "Type 327" CRO is a medium-frequency medium-priced instrument designed primarily to fill gap resulting from industry trend to concentrate on LF or HF instruments.—*Instrument Div., Allen B. DuMont Labs., Clifton, N. J.*



For more information circle **318** on inquiry card.

Reflection-coefficients Plotter

New "*Z-g* Diagraph" instantaneously plots, by means of a light spot, complex impedances and admittances directly on a Smith or similar chart; obviates laborious measurements and calculations. Charts: (1) reading directly in terms of reflection coefficient, (2) standard Smith chart, (3) chart calibrated to give unknown impedance in terms of magnitude and phase angle, (4) an expanded portion of center of Smith chart; also a chart for transmission characteristics of four-terminal networks such as filters and attenuators. Two models: "ZDU," 30 to 300 Mc., and "ZDD," 300 to 2400 Mc., both have characteristic impedance of 50 ohms.—*Instrument Div., Federal Telephone & Radio Co., Clifton, N. J.*

For more information circle **317** on inquiry card.

Tube-tester Chart

New "No. 625-04 Tube Tester Roll Chart" contains hundreds of listings of latest tubes; is printed on a 6-ft.-long continuous sheet of durable paper.—*Electronic Instrument Co., 84 Withers St., Brooklyn 11, N. Y.*

For more information circle **319** on inquiry card.

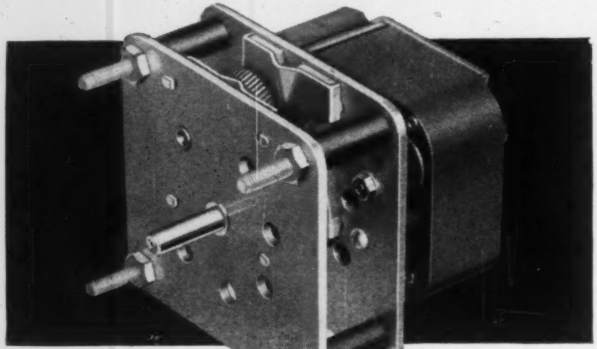
Circuit Tester

New Universal Continuity Meter will not damage delicate components or expensive instruments; differentiates between legs of high-current filament circuits; indicates sources of

BARBER COLMAN

Barcol®
Small Motors

now with new, improved gear reduction for radial thrust and overhanging loads

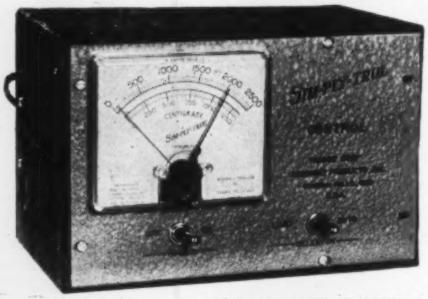


Here's a versatile, new open-type geared Barcol motor in a *double-plate assembly* for extra ruggedness, quietness, and dependability. Heavy duty gears and output shaft. Helical pinion and first gear provide quiet operation. Sintered bronze bearings lubricated by extra large oil wicks. In gear ratios from 4:1 to 30,000:1. Starting torques up to 75 lb-in. Choice of synchronous or non-synchronous unidirectional motors, or non-synchronous reversible motors. High torque to inertia ratio of reversible motors is ideal for servomechanisms. Write for illustrated Bulletin F-6841 on Barcol DYAZ Motors.

Barber-Colman Company Dept. P, 1215 Rock St., Rockford, Ill.

For more information circle **65** on inquiry card.

SIMPLYTROL AUTOMATIC PYROMETER



10 temperature ranges cover from -75° to 3000°F.

Several special ranges to -400°F.

Cat. No. 4531 0/2500° F.
Price $132.00

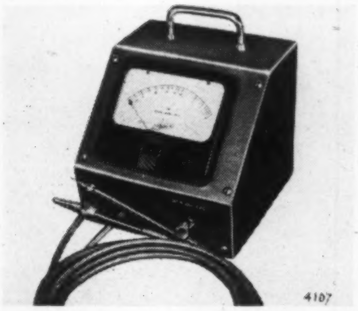
Thermocouple type Automatic Pyrometer for controlling temperature in furnaces, ovens, and processes. The Simplytrol is economical and reliable with few moving parts. There are no vacuum tubes. The regular load relay is S.P.D.T. 5 Amps. Optional heavy duty relays to 40 Amps.

10 temperature ranges cover from —75° to 3000° F. Several special ranges to —400° F. "On & Off" control for holding the desired temperature works on gas, oil or electric heat. Indicating meter-relay is medium high resistance and has bimetal cold junction compensation. For use with all standard thermocouples. Accuracy 2%.

"Auto-Limit" switch changes Simplytrol from automatic controller to limit pyrometer for safety shut down or warning. Cabinet: 6½x6½x9½ inches. Also flush panel mount models. Send for new Bulletin G-7 for more data. Assembly Products, Inc., Chesterland 10, Ohio.

"See us at I.R.E. Conf. Westward Ho, Phoenix, 4/28, 29"

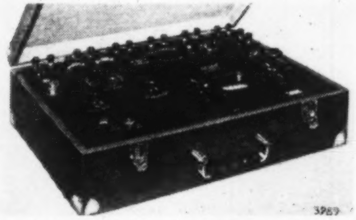
For more information circle **66** on inquiry card.


4107

trouble in switches, relay contacts and connectors; locates incomplete electrical bonding and detects unsoldered and "cold" soldered connections; can be operated by inexperienced personnel.—*Amelco, Inc., Dept. 27, 2040 Colorado Ave., Santa Monica, Calif.*
For more information circle **320** on inquiry card.

Transformer Test Set

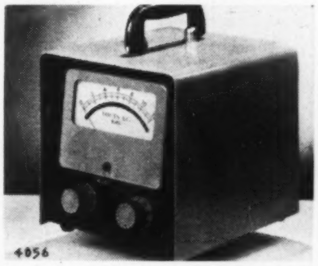
New "METH 2" portable transformer test set employing differential method measures ratio and angle errors of current transformers with secondary rated currents of 1 to 10 amps plus 20 percent and of potential transformers with secondary rated voltages from 46 to 140 v., at frequencies from 16⅔ to 60 cps.—*Hartmann & Braun AG, Frankfurt am Main West 13, Germany.*


3989

For more information circle **321** on inquiry card.

Expanded-scale Voltmeter

New "Model 101" covers 100-500-v. range in 39 easy-to-read steps. Accuracy better than 0.25 percent. Frequency response uniform between 50 and 2000 cps. Connections for continuous recording of line voltage fluctuations with a 1-ma. d-c. recorder.—*Shasta Div., Beckman Instruments, Inc., 1432 Nevlin Ave., Richmond, Calif.*


4056

For more information circle **322** on inquiry card.

Picture-tube Tester

New "Model 590" provides a complete test of the quality of a TV picture tube; places an actual raster on face of picture tube; tests tubes under actual operating conditions; has definite and accurate rejection limits; measures light output with a photo-

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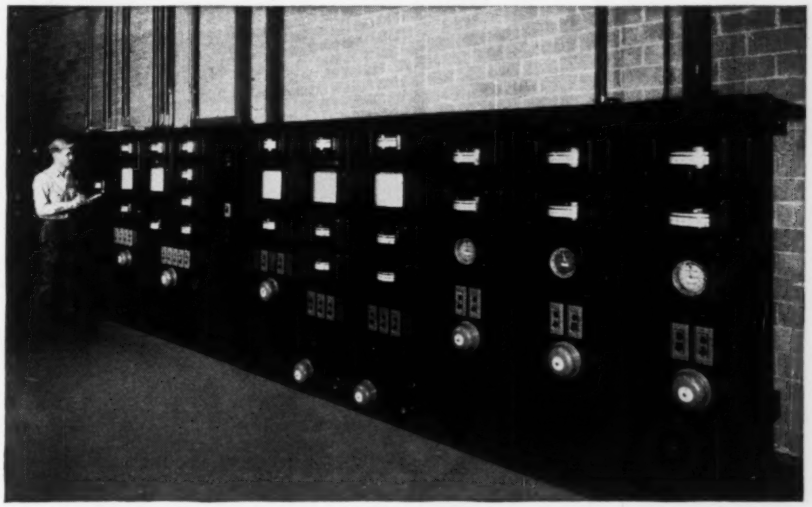
BARBER
COLMAN

Wheelco Control Center



Brings automation to heat treating!

This specially engineered Wheelco Control Center provides complete instrumentation necessary for fully automatic heat-treating of oil well drill bits. Temperatures and heating cycles of carburizing, hardening, and drawing furnaces are precisely controlled from the central panel. Continuous, 24-hour process is completely mechanized. Wheelco Instruments simplify servicing . . . provide maximum standardization and interchangeability of "plug-in" components . . . assure dependability needed for continuous-flow, low-cost heat-treating. Let Wheelco's Instrument Engineering Service recommend profit-saving solutions to your special control problems.

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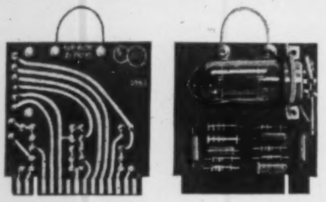
Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Small Motors
Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

For more information circle **67** on inquiry card.

CUT DESIGN TIME
WITH
EECO
PLUG-IN
UNITS
FOR COMMERCIAL
AND MILITARY
APPLICATIONS

FLIP-FLOP PLUG-IN TYPE Z-90048
(0 to 1 Megacycle)

EECO plug-in circuitry reduces engineering —design and production time . . . cuts costs and performs with the highest degree of reliability. The Z-90048 flip-flop (shown above) is a typical high speed bi-stable multivibrator designed for counting and frequency division applications. Binary operation ranges from 0 to above 1 megacycle. The 11 pin base increases flexibility, so that binary counting, counting employing feedback, and re-setting may be readily accomplished. Output of one Z-90048 will drive a similar following unit without amplification.



EECO ETCHED CIRCUITRY
FLIP-FLOP PLUG-IN UNIT Z-91000

Here is another reliable EECO plug-in unit . . . the Z-91000 Flip-Flop utilizing etched circuitry.

This is a medium speed bi-stable multivibrator circuit for applications in counting, frequency division, switching and time selection. Units are wired for linear binary or feedback counting applications.

Write for other Technical Data on Complete Line of EECO Standard Plug-in Units and Custom Engineered Circuitry

EECO PRODUCTION COMPANY
827 South Vermont Avenue Los Angeles 5, Calif
a subsidiary of
electronic engineering company of california

For more information circle **68** on inquiry card.

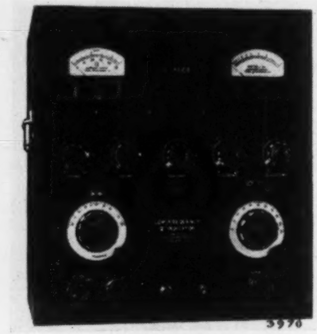
(Dynamic Mutual Conductance tube tester)
Closed
Open

cell; also serves as picture tube rejuvenator.—*The Hickok Electrical Instrument Co., 10528 Dupont Ave., Cleveland 8, Ohio.*

For more information circle **323** on inquiry card.

L-f. *Q* Indicator

New design of maker's "Type 1030-A Low Frequency *Q* Indicator" extends accuracy of *Q* measurement

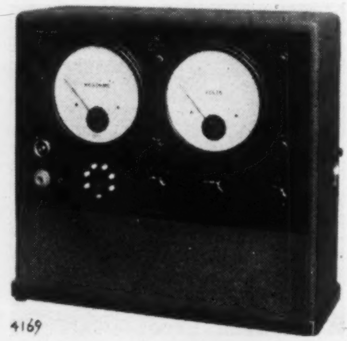


through low audio and upper supersonic frequency range.—*Freed Transformer Co., Inc., 1715 Weirfield St., Brooklyn 27, N. Y.*

For more information circle **324** on inquiry card.

High-insulation Testers

New "Tera-Ohmmeters" are available for ranges from 0.2 megohm to 500 teraohms (500 × 10^{12} ohms);


4169

are produced by R. Jahre (West Germany). Test samples can be measured grounded, ungrounded or with guard-ring electrodes. Operation is from line or self-contained batteries. Measurements are made to ASTM standards. —*Instrument Div., Federal Telephone and Radio Co., Clifton, N. J.*

For more information circle **325** on inquiry card.

Transistor Tester

New *n-p-n* or *p-n-p* junction transistor tester incorporates direct reading calibration by a single knob ad-

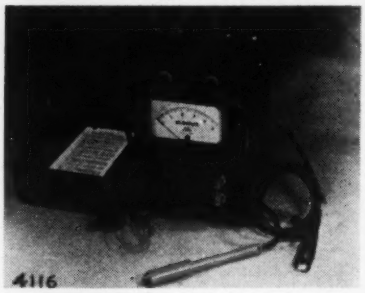
JUNCTION TRANSISTOR TESTER
4145

justment; conversion from beta to alpha values by means of a simple table or curve (both supplied with unit); is suited for production lines, labs, and service establishments. Test frequency of 270 cps. is used by most transistor manufacturers and meets military specs.—*Devenco Inc., 150 Broadway, New York 38, N. Y.*

For more information circle **326** on inquiry card.

Insulation Test Set

New "Model 405A" rated 0-5000 v.a.c. completes line of "Hypot Juniors," features continuously variable

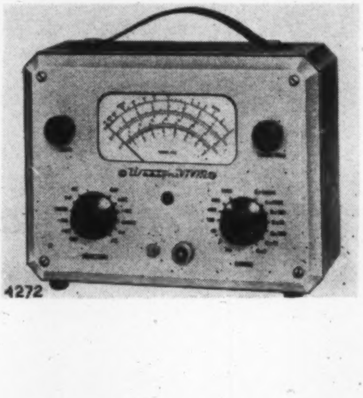

4116

output voltage, current-limiting high reactance transformer, a neon "breakdown" lamp to indicate arcing or corona in test circuit, a neon "leakage" lamp to indicate excessive current flow, grounds and short circuits, and kilovoltmeter connected directly across output. Input is 115 v.a.c. 60 cps.—*Associated Research, Inc., 3766 W. Belmont Ave., Chicago 18, Ill.*

For more information circle **327** on inquiry card.

VTVM

New "Model 982" self-contained vacuum tube voltmeter is adaptable where requirements of peak-to-peak measurements exclude use of conventional instruments; is battery-operated; is completely isolated from spur-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THE VALVE THAT CONQUERS FLASHING CONDENSATES

Better Control, with Lower Initial and Maintenance Costs

- *Eliminates special construction*
- *Eliminates liners*
- *Minimizes downstream piping erosion*
- *Eliminates cavitation*
- *No welded-in seat rings*

Use Annin Valves—automatic, remote operated cylinder, and manual valves—for flashing condensates at all pressures and temperatures.

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Control
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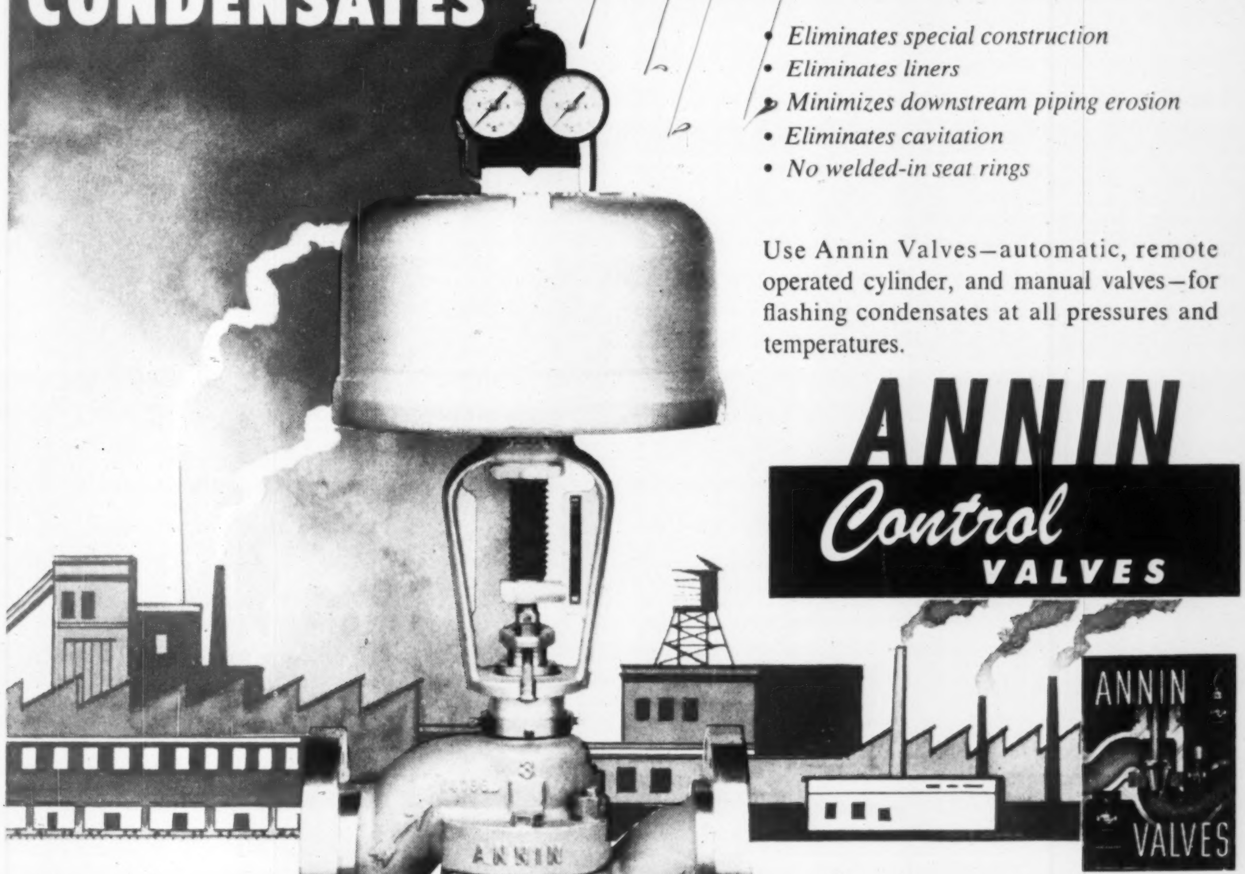

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For more information circle **69** on inquiry card.

Fast
OR
Slow

. . . any moving metal object

"AUTOMATES" YOUR OPERATION

or ACTUATES INSTRUMENTS

through these

ELECTRO PICK-UPS

. . . without contact or "loading"

PROXIMITY PICK-UP SYSTEM

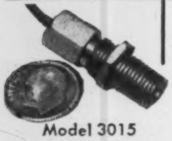
Model 4900

Ideal for use where actuating object moves slowly. A high frequency carrier-operated transducer that works on a principle like that of a military mine detector. A constant amplitude of 5 volts is produced when any metallic mass is brought near the pick-up. Output voltage is independent of the speed of the actuating object. Voltage can be amplified to do mechanical work synchronized with the exciting object or fed to a measuring or counting instrument.

MAGNETIC PICK-UPS

Model 3010-A

Produce AC voltage proportionate to rate of motion of any magnetic metal object traveling 3" per second or faster.



Model 3015

For use where space is limited—same speed ratio characteristic as the 3010-A . . . up to 25% of its output.

Electro Pick-ups are actuating synchronized automatic operations in many industries—send today for details of how they can work for you!

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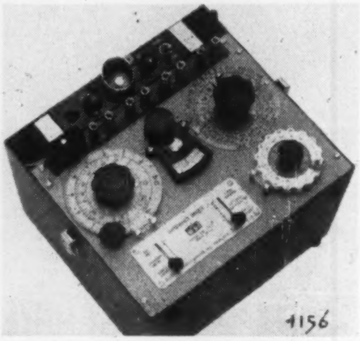
For more information circle **70** on inquiry card.

ious response due to stray a-c. fields and circulating ground currents. Peak to peak measurement with an input impedance of 10 megohms shunted by only 15 micromicrofarads prevents circuit loading.—*Weston Electrical Instrument Corp., Newark 5, N. J.*

For more information circle **328** on inquiry card.

Impedance Bridge

New "Model 250-DA" is for measurement of resistance, capacitance, inductance, dissipation factors, and storage factors; operates from a.c. line; uses carefully stabilized capacitance standard adjusted to better than 0.15 percent. Operating limits 0.1 milliohm to 12 megohms in 8 ranges, 0.1 uuf. to 1200 uf. in 7 ranges, 0.1 microhenry to 1200 henrys in 7 ranges, 0.001 to 1.0 for dissipation factor, and 0.02 to 1000 for storage factor. Impedance measurements are extreme precision. — *Electro-Measurements, Inc., 4312 S. E. Stark St., Portland 15, Ore.*



For more information circle **329** on inquiry card.

Pocket Volt-ohmmeter

New "Model 355 Midgetester," said to be the world's smallest practical VOM, has 14 measurement ranges, 10,000 ohms per volt sensitivity on both ac. and dc.; features 0.1-ma. self-shielded movement.—*Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.*

DCV
3
12
ACV
60
300
1200
x1000
OHMS
x1
x10
x100
Simpson
422625

For more information circle **330** on inquiry card.

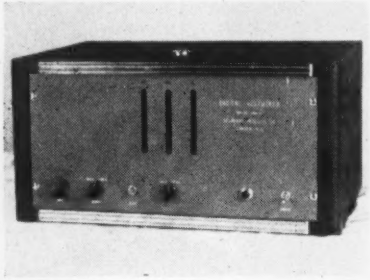
Simulator Instruments

New complete line of simulator instruments is for computer manufacturers, aircraft design groups studying flight performance, radar trainer designers, etc. Though designed to simulate aicraft instruments, they are readily adaptable for use in other applications; are actuated by computer output or other electrical means; are of 60-cps., 400-cps. and d-c. designs.—*Link Aviation, Inc., Binghampton, N. Y.*

For more information circle **331** on inquiry card.

Digital Voltmeter

New digital d-c. voltmeter reads from 000 to 999, calibrated as volts, millivolts, etc. Multiple ranges available, and both positive and negative voltages may be measured. More than 20 readings per second are possible. Principle: converting voltage levels to time intervals, and indicating time as counts. A standard cell is used as internal reference. Standardization is continuous; no manual standardization necessary.—*Delaware Products Co., 811 Broadway, Camden 3, N. J.*



For more information circle **332** on inquiry card.

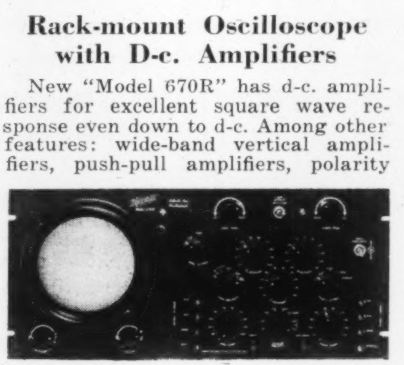
Oscilloscope

New "Type 324" is said to be the first commercial CRO with complete precision calibration and extremely high sensitivity, that enables observation and measurement in microvolt region without pre-amplification. Frequency response is flat from dc. to 300 kc., depending on sensitivity range. Both driven and recurrent sweeps available with automatic beam-brightening.—*Instrument Div., Allen B. Du Mont Laboratories, Inc., Clifton, N. J.*

For more information circle **333** on inquiry card.

Rack-mount Oscilloscope with D-c. Amplifiers

New "Model 670R" has d-c. amplifiers for excellent square wave response even down to d-c. Among other features: wide-band vertical amplifiers, push-pull amplifiers, polarity

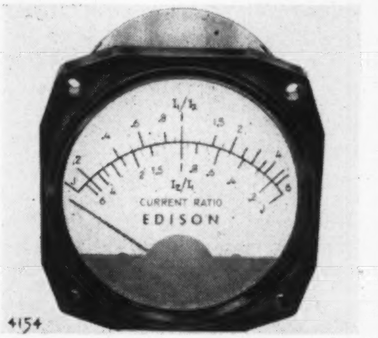


reversing switches, horizontal attenuator and Z-axis (intensity modulation post) on front panel. Recurrent linear sweep 3 to 50,000 cps.—*The Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

For more information circle **334** on inquiry card.

Ratio Meter

New panel instrument indicates ratio of two direct currents, up to 50 ma. in either coil; will accurately indicate a ratio on an input of 2 ma. minimum. Scale tolerances are based on angular tolerance of 1 deg.—*Instrument Div., Thomas A. Edison Inc., West Orange, N. J.*



For more information circle **335** on inquiry card.

Differential Voltmeter

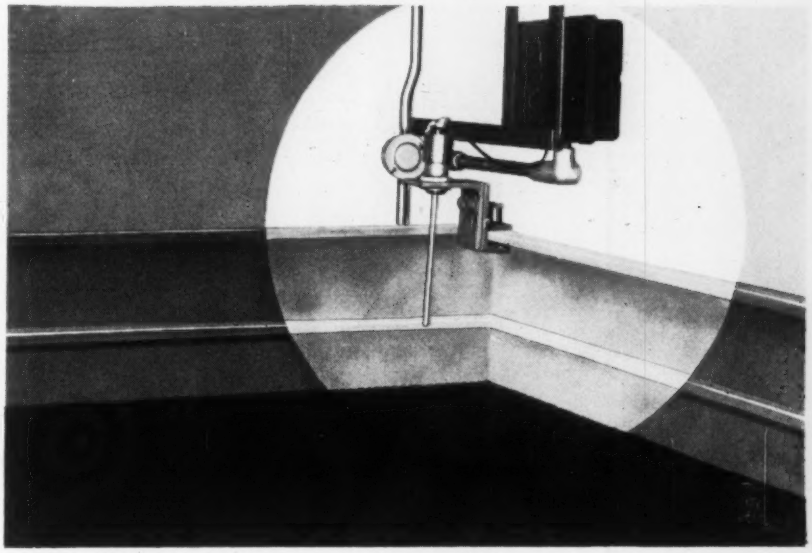
New "Model 800 Differential Vacuum Tube Voltmeter" is a 0-500-v. potentiometer (using a Standard Cell); better than 0.1 percent accuracy; resolution 10 mv. over entire range and read directly off last decade. Zero-center VTVM serves as both null indicator and calibrated deviation meter. Input resistance infinite at null and 2000 megohms/v. of input when 0.005 v. off null.—*John Fluke Mfg. Co., Inc., 1111 W. Nickerson St., Seattle 99, Wash.*

For more information circle **336** on inquiry card.

Voltage-ratio Standard

New "Model 592 Standard Voltage Ratio Comparator" is used for setting accurate voltage ratios, both a-c. and d-c., by means of an accurately calibrated voltage-divider network and a zero-center microammeter. It measures ratios from 1:1 to 10,000:1 with accuracy of 0.01 percent, in range of +150 to −150 v.dc.; compares voltages across 120 v.ac. 350-cps. source; can be supplied to compare a-c. voltage

TEKTOR Keeps Hershey Chocolate from Overflowing Open Tank

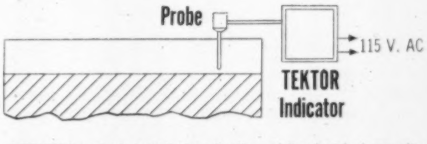


How to keep a 90,000 pound open milk chocolate storage tank from overflowing was the problem faced by the Hershey Chocolate Corporation.

Hershey Engineers found a solution by installing a Fielden TEKTOR High-Level Indicator Controller and Probe. Now, when chocolate level rises to 4 or 5 inches from the tank lip, this simple but dependable instrument flashes and sounds a warning so that the inflow of chocolate can be stopped.

Why TEKTOR Level Control is YOUR Solution

- Indicates or controls level of fluids, powders, solids (conducting or non-conducting)
- Electronically controls level as close as 1/16"
- A ready-to-install unit
- No moving parts . . . only one radio tube
- Regular plant personnel can maintain it
- Low first cost . . . low operating cost.



A TEKTOR probe is installed vertically and its electrical capacity changes when chocolate level is 4 or 5 inches from the lip of the tank. This de-energizes the Indicator relay and switches on the warning light and alarm.

Fielden
TEKTOR

Robertshaw-Fulton
CONTROLS COMPANY

Send this coupon today, and find out how Fielden Simplified Instrumentation can solve your process control problems . . . accurately and economically.

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Please send me bulletins about your low-cost, accurate controls.

☐ TEKTOR Level Control
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☐ Resistance Thermometer Recorder
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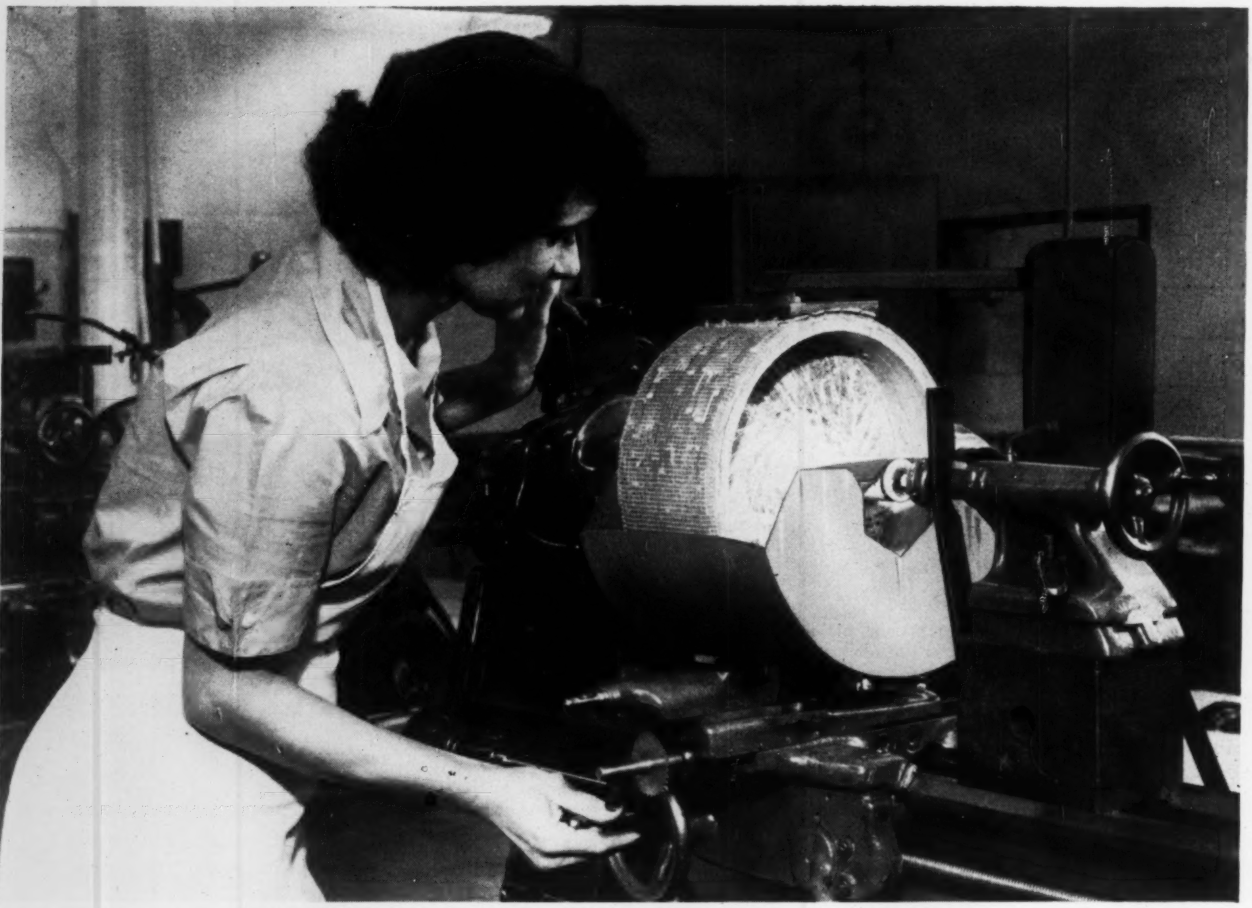
COMPANY______________________ ADDRESS______________________
CITY______________________ STATE______________________

For more information circle **71** on inquiry card.



5000 GALVANOMETER LENSES are being polished at one time on a special Houston Technical Laboratories device on the precision optical components production line.

HTL mass production means better galvanometer optics!

. . . custom made . . . delivered promptly!

You get the advantage of mass production prices and prompt delivery when you order custom made galvanometer mirrors and lenses from Houston Technical Laboratories — the world's largest commercial producer of precision galvanometer optical components. Mass production methods have enabled HTL to develop important exclusive features and to maintain unusually high quality standards at competitive prices.

Miraloy — an exclusive HTL mirror coating — is but one of the advantages you get when you specify HTL galvanometer mirrors. With reflectivity approximating that of pure aluminum, *Miraloy* provides a hard, corrosion and heat resistant surface — far superior to all other standard coatings.

square-cut edges on all HTL galvanometer mirrors make possible firm, dependable mounting by the saddle technique. Precise diamond cutting eliminates irregular edges regardless of mirror size or shape.

prompt delivery is still another important HTL advantage. Mass production techniques assure delivery of galvanometer mirrors within 3 weeks of your order.

custom made to exact specifications, HTL galvanometer mirrors are produced in flat, spherical, or cylindrical shapes and in sizes as small as 0.0025″ in thickness and 0.010″ in length and width. Thickness tolerance can be held to 0.0002″, and the length and width tolerance to 0.0005″. Galvanometer lenses are produced to your desired specifications.

low unit cost, resulting from HTL's unique mass production techniques, is still another important reason for sending your specifications to Houston Technical Laboratories. HTL galvanometer mirrors and lenses, superior in quality, are priced surprisingly low.

TWENTY-FIFTH YEAR
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GEOPHYSICAL INSTRUMENTATION

For further information about HTL precision optics, write for Bulletin No. 0-101.

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A SUBSIDIARY OF TEXAS INSTRUMENTS INCORPORATED
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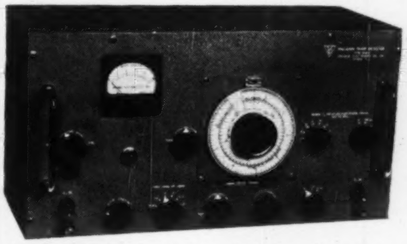
For more information circle **72** on inquiry card.

ratios at any frequency. Unit weighs 25 lbs.; requires external power sources.—*Telectro Industries Corp., 35-18 37th St., Long Island City* 1, *N. Y.*

For more information circle **337** on inquiry card.

Combination Phasemeter

New "Type 250a Precision Phase Detector" measures time delay, phase delay, or envelope delay with error less than 1 percent or 0.1 deg. between two alternating voltages from 10 kc. to 15 Mc. Smallest time delay readable on dial is 5×10^{-10} sec.; smallest phase angle $5 \times 10^{-10} \times 360 \times$ frequency in cps.—*Advance Electronics Co., Inc.,* 451 *Highland Ave., Passaic, N. J.*



For more information circle **338** on inquiry card.

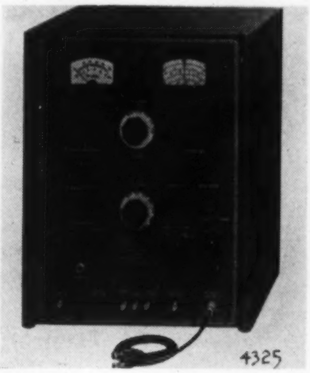
Signal Tracer

New "Model 147 Deluxe Multi-signal Tracer," available in both kit and wired form, provides facilities for RF, IF and audio signal tracing and trouble-shooting in AM, FM and TV sets.—*Electronic Instrument Co.,* 84 *Withers St., Brooklyn* 11, *N. Y.*

For more information circle **339** on inquiry card.

Sweep Generator

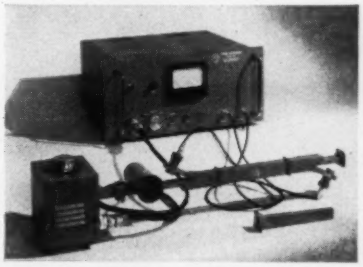
New "Type 240-A" multi-purpose precise signal source can be used as a single-frequency source, an AM signal generator, a sweep frequency signal generator with frequency deviation variable over a wide range (4.5 to 120 Mc.) and a sweep frequency signal generator with frequency identifying marks. Single frequency output can be calibrated against internal crystal controlled frequencies.—*Boonton Radio Corp., Boonton, N. J.*



For more information circle **340** on inquiry card.

X-band VSWR Indicator

New "Model 110B X-Band VSWR Measuring System" has speed and accuracy of earlier models, plus added attenuation scale and new VSWR scales reading from 1.02 to 1.20 and 1.1 to 2.50.—*Color Television Inc.,* 1017 *E. San Carlos Ave., San Carlos, Calif.*



For more information circle **341** on inquiry card.

VOM Kit

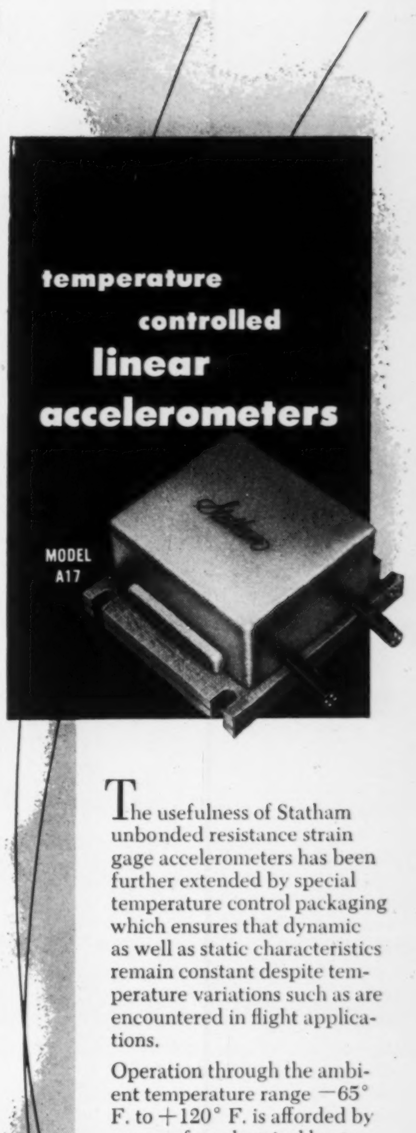
New "Knight" 20,000 ohm/volt VOM kit features an improved circuit and careful placement of parts to assure simplicity of construction. Nineteen ranges: 6 d-c. voltage 6 a-c. voltage ranges 0 to 5000; 3 resistance ranges 0 to 200 megohms; and 4 direct current ranges 0 to 10 amps. Supplied with 4-ft. test leads and instructions.—*Allied Radio Corp.,* 100 *N. Western Ave., Chicago* 80, *Ill.*

For more information circle **342** on inquiry card.

Dial Drives

New synchronous-motor drive unit is available for "Types 907 and 908" precision gear-drive dials (also available as separate units). Two models are available, with output speeds at driving pinion of 4 rpm. and 30 rpm. respectively. Motor characteristics are such that drive reverses itself whenever a stop is encountered.—*General Radio Co., Cambridge* 39, *Mass.*

For more information circle **343** on inquiry card.



temperature controlled linear accelerometers

The usefulness of Statham unbonded resistance strain gage accelerometers has been further extended by special temperature control packaging which ensures that dynamic as well as static characteristics remain constant despite temperature variations such as are encountered in flight applications.

Operation through the ambient temperature range −65° F. to +120° F. is afforded by means of an electrical heater jacket with a peak power input of approximately 20 to 30 watts.

Depicted is the Model A17 accelerometer which is offered in ranges from ±1g to ±15g. Other temperature controlled models cover ranges from ±0.5g to ±15g.

Please request Catalog Bulletin No. AT-1.

Statham LABORATORIES, INC.
12401 W. Olympic Blvd. • Los Angeles 64, Calif.

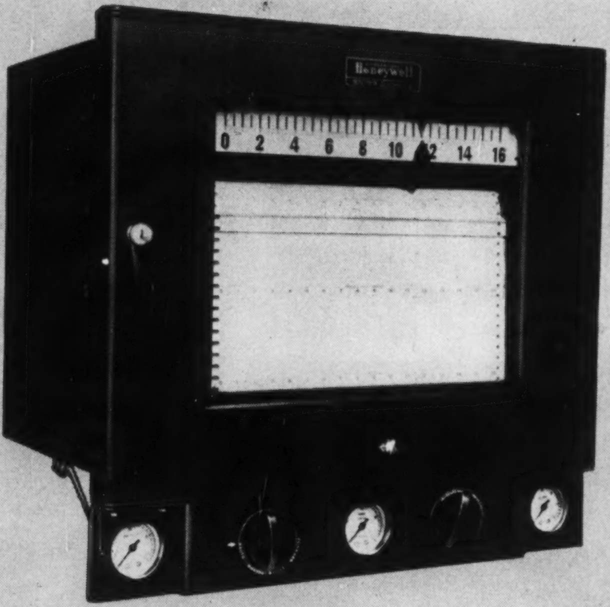
For more information circle **73** on inquiry card.

STRIP CHART

ElectroniK

Controllers

. . . preferred for applications that require highly detailed records on 11-inch-wide charts covering weeks of operation. Control point can be set to desired value with high precision. Automatic standardization on all potentiometer models. Supplied with or without integral by-pass.

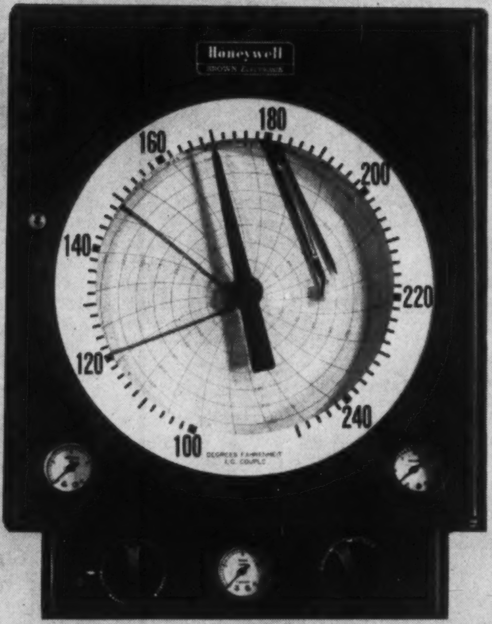


CIRCULAR CHART

ElectroniK

Controllers

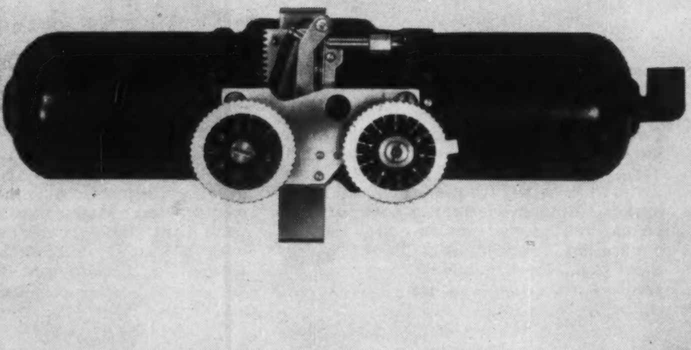
. . . provide high accuracy and high readability of the indicated value. 12-inch circular charts are convenient size for filing. Push-button standardization on potentiometer models. Available with or without integral by-pass panel.



Air-O-Line

CONTROL UNIT

. . . capable of handling practically any control problem, with proportional action and automatic reset. Proportional band width is adjustable up to 150%. Liquid reset system needs no volume or capacity tanks . . . provides linear reset rate. Reset action continues as long as the pen is off the set point. Rate action may be added when required. The complete unit is sealed, interchangeable, readily adjustable. Simple, sturdy design assures reliable operation.



For more information circle **74** on inquiry card.

Design for *extra* precision and flexibility— use *ElectroniK* instruments with **Air-O-Line** control

WHENEVER a process calls for air-actuated control, here's an unbeatable combination that fills the bill as no other can . . . *ElectroniK* instruments with *Air-O-Line* control. In these controllers are joined the speed, precision and dependability of *ElectroniK* measurement, plus the flexibility and sensitivity of the *Air-O-Line* control system.

Versatile *ElectroniK* instruments are applicable to an almost unlimited variety of variables—temperature, flow, pH, chemical composition, liquid level, weight of solids. With their *Air-O-Line* system, they provide the peak in performance as individual controllers or in cascade circuits.

In every detail, these controllers are engineered with the instrument man in mind. Air gages and adjustment dials are spotted for maximum convenience. Every component is precision-made, with plenty of reserve strength built in to assure long, trouble-free service . . . and assembled into a compact unit in which all parts are available for easy inspection and maintenance.

Compare the features of these controllers . . . and you'll see why quality-conscious and economy-conscious designers choose them for so many vital process responsibilities. For a discussion of how you can use them in your own applications, call your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division,*
Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada,
Toronto 17, Ontario.

- **REFERENCE DATA: Write for Catalog 1531, "*ElectroniK* Controllers."**

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First in Controls

For more information circle **74** on inquiry card.

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SECONDS
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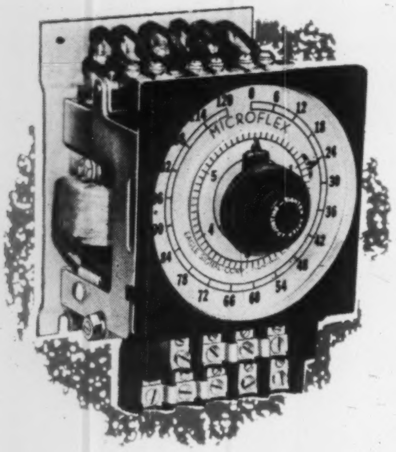

Are your machines adaptable to different jobs — some requiring seconds — others requiring minutes?

The Microflex Timer with its micrometer accuracy and large, easy to read, wide range dial, makes this variation easily and quickly adjustable.

The Microflex is designed for outstanding ruggedness and dependability. Take advantage of the outstanding features of this timer for your processing machines.

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by **EAGLE**

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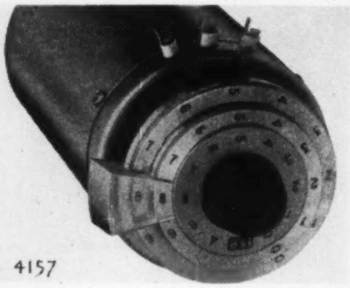
MOLINE, ILL.

For more information circle **75** on inquiry card.

Decade Capacitors

New "Dekapacitors" represent a completely new type, feature exceptional stability, high accuracy, and low dissipation factors through use of polystyrene capacitors and precision structural components. Any incremental capacitance value can be selected throughout 0 to 1 microfarad range within 1 percent accuracy by new style Dekadial."—*Electro-Measurements, Inc.*, 4312 *S. E. Stark St., Portland* 15, *Ore.*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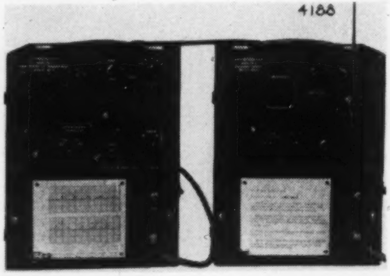
For more information circle **344** on inquiry card.

FM Frequency Divider

New "FM-5" extends frequency measuring range of "FM-3" or "AM-1" down to 50 kc. and frequency generating range down to 200 kc. with no loss of accuracy; measures and generates up to 20 Mc. with continuous coverage. It comprises two tuned frequency dividers in cascade, each dividing by ten.—*Gertsch Products, Inc.*, 11846 *Mississippi Ave., Los Angeles, Calif.*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For more information circle **345** on inquiry card.

Capacitor Box

4161

New "Model 1120 Capacitor Substitution Box," available in both kit and factory-wired form, enables rapid substitution of a wide range of RETMA capacitance values in an operating circuit to determine value needed for optimum performance; also helps find value of badly damaged or otherwise illegible capacitors. Range 0.0001 to 0.22 uf.; most capacitors rated at 600 v., lowest rating 400 v.—*Electronic Instrument Co., Inc.*, 84 *Withers St., Brooklyn* 11, *N. Y.*

For more information circle **346** on inquiry card.

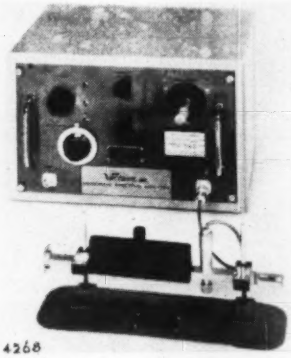
Marker-generator

New "Ultra-Marker," for use with a sweeping oscillator, develops a 'scope display marker signal at all UHF sound and picture frequencies covered by an associated sweeping oscillator. Switching system eliminates all but every fourth set of channel markers. Complete with regulated power supply. All controls front-panel located.—*Kay Electric Co., 14 Maple Ave., Pine Brook, N. J.*

For more information circle **347** on inquiry card.

K-Band RF. Heads

New "K-Band R.F. Heads," covering microwave spectrum from 12,400 to 40,000 Mc. are complete microwave tuning units, were specifically designed for use with maker's "SA25 Microwave Spectrum Analyzer," but earlier models of this analyzer, as well as other analyzers, can be modified or adapted to use new these assemblies. —*Vectron, Inc., 386 Main St., Waltham 54, Mass.*



For more information circle **348** on inquiry card.

POWER SUPPLIES

Dual-range D-c. Supply

New "Model EF," for operation and testing of electronic equipment, has a-c. hum or ripple less than 1 percent at 5 amps.; provides a continuously-variable source for voltages from 0 to 14 and 0 to 28. Current and voltage are indicated on d'Arsonval-type instruments. Weight 28 lbs.—*Electro Product Labs., 4503 N. Ravenswood, Chicago 40, Ill.*

For more information circle **349** on inquiry card.

300-amp. Supply

New "Model No. MR2232-300" tubeless magnetic-amplifier-regulated power supply is rated at 22-32 v.dc., 300 amp.; operates from 230/460 volt 3 phase 60-cps. ac. input with 10 percent tolerance on input voltage. Floor-mounted cabinet dimensions 30 x 25½ x 72 in.; weight 500 lbs.—*Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.*

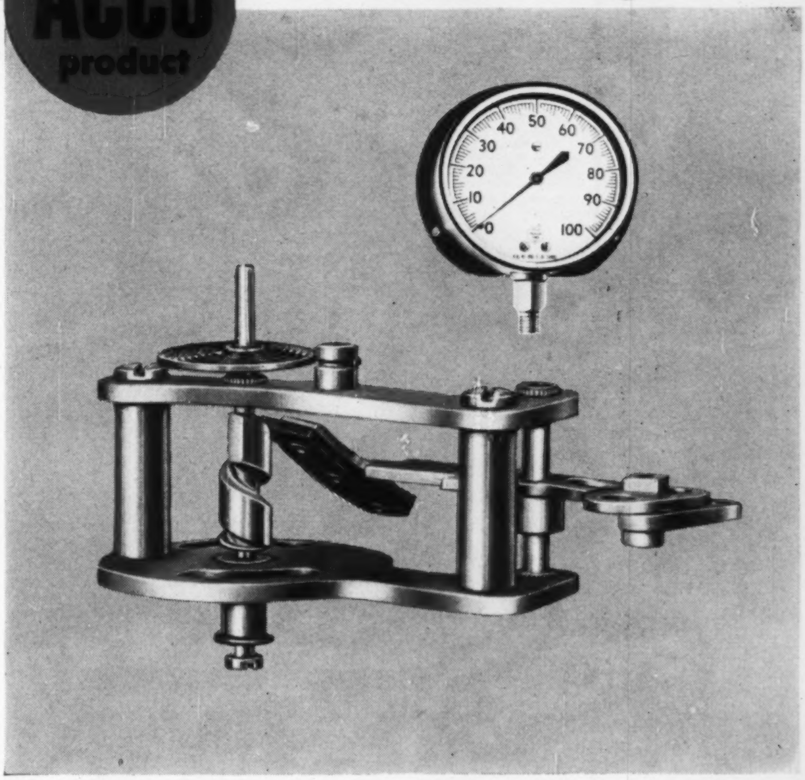
For more information circle **350** on inquiry card.

Regulated Power Supply

New "Model 312" is a combination d-c. and a-c. line regulated power supply, suited for life testing racks, computers, etc., where low heat dissi-

an ACCO product

Helicoid Gages



Use Gages? Does sustained accuracy for over 75,000,000 cycles (at 1200 pulsations per minute) interest you?

• It's the basic design of HELICOID Gages that makes them outlast and out-perform ordinary gear-tooth gages. This enduring accuracy is evidenced by the smooth rotation of simple spiral roller and cam.

If you use gages it will pay you to investigate HELICOID performance records. There is a HELICOID long-life gage to meet every type of pressure indicating requirement. Ranges are to 20,000 p.s.i. and vacuum or compound.

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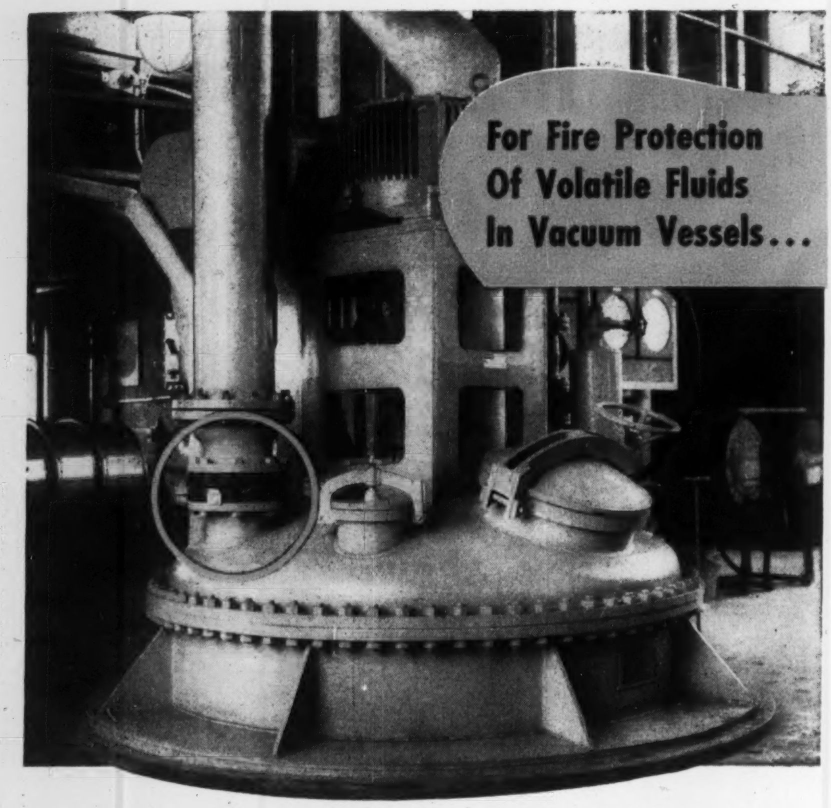

The Formica Company Uses

BS&B SAFETY HEADS!

In the Formica Company's Evendale, Ohio, plant are four large high-vacuum vessels used for the impregnation of basic raw material with resins and varnish. These substances are, of course, even more volatile in a partial vacuum than at atmospheric pressure, and a single spark could set them off.

To protect each vessel from explosive destruction in case ignition of its contents *does* occur, an 8-inch BS&B SAFETY HEAD is utilized. This SAFETY HEAD acts as a *controlled* weak spot in the vessel, and would fail *safely*, with minimum danger from fire, at a lower pressure than the vessel itself.

Future plans of the Formica Company call for additional resin processing vessels, and they too will be protected with BS&B SAFETY HEADS!

If you aren't already using BS&B SAFETY HEADS in *your* plant to safely handle pressure relief problems, we'd suggest you get in touch with your nearest BS&B Representative without delay. Or, write for Catalog and full information . . . no obligation!

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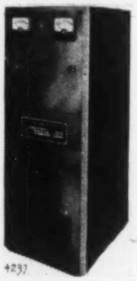
For more information circle **77** on inquiry card.

pation, no warm-up time, long life, and stable operation are basic requirements. Output continuously variable 0-3/30/300 v.dc. in three ranges, or 0-130 v.ac. Output current 250 ma. dc. or 1 amp. ac.—*Electronic Research Associates, Inc., Caldwell, N. J.*

For more information circle **351** on inquiry card.

Industrial Rectifiers



New selenium rectifiers have a power factor of 97 percent; d-c. ripple of approx. 4 percent. Any number may be paralleled. Available in many models for every industrial application. No moving parts. Oversize components used throughout; copper bus bars operate at low current density.—*Walker Div., Norma-Hoffman Bearings Corp., Stamford, Conn.*

For more information circle **352** on inquiry card.

Mag.-amp. D-c. Supply

New "EM-28-1B" tubeless magnetic-amplifier-regulated d-c power supply, developed for airborne applications, is equally adapted to lab use to operate strain gages and instruments requiring precise regulation and low ripple. Size 12 by 7 by 9 in. (same space as battery it replaces). Delivers continuously 0 to 1.5 amps.; voltage range of 28 to 32 v.dc. Recovery time is better than 0.2 sec. under worst conditions.—*Engineered Magnetics, 11812 Teale St., Culver City, Calif.*

For more information circle **353** on inquiry card.

30-watt Hv. Supply

New "Encapsulated High-voltage Power Supply," suitable for aircraft installations, meets MIL-E-5400; operates from 115 v.ac. 400-cycle source; delivers 5.1 kv. at 7.5 ma. as well as 6.3 v.ac. at 1.5 amp. and 6.3 v.ac. at 0.5 amp.; will operate over range of –62 C. (–80 F.) to 85 C. (185 F.); weighs less than 6½ lbs.—*Telectro Industries Corp., 38-18 37th St., Long Island City 1, N. Y.*

For more information circle **354** on inquiry card.

Battery Charger

New manifold battery charger can charge one to five 24-v. aircraft batteries, one to ten 12-v. batteries, etc. Height 21 in., can be wall mounted; has built-in fuse protection, ammeter, voltmeter, and current control from trickle to maximum charging.—*The Electronic Rectifier Co., Rochester, N. Y.*

For more information circle **355** on inquiry card.

D-c. Power Supply

New "MagniVolt" non-electronic regulated selenium rectifier provides 5 to 30 amps., 4 to 30 v. dc. Regulation 1 percent from no-load to full-load with line voltage variation of 100 to 125; response 0.2 second under extreme load conditions; ripple 1 percent rms. (also available with 0.1 percent). Incorporates two indicating instruments, standard a-c. input switch, fuse, pilot light, input and output posts.—*Inet, Div. Leach Corp., 4441 Santa Fe Ave., Los Angeles 54, Calif.*

For more information circle **356** on inquiry card.

AMPLIFIERS

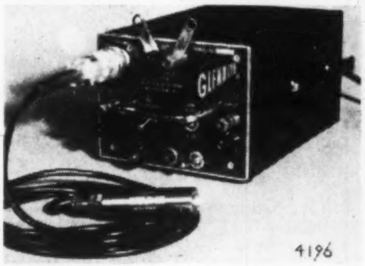
Magnetic Amplifiers

New "Ultra-Fast Magnetic Amplifiers" feature (for first time in a magnetic amplifier) speed of response independent of number of stages of amplification; are 3-stage amplifiers in which input and output phase occur during the same half cycle of power supply. Reduction of series major loop lag permits use of more negative feedback in inner loop, whence improved stability. Power gain 50,000.; power output: a-c. 15 watts phase-reversible with a-c. input, d-c. 15 watts polarity reversible with d-c. input; total time lag: 0.0083 sec.; weight: 10 lbs.; dimensions: 6x5x10½ in.—*Librascope, Inc., 808 Western Ave., Glendale, Calif.*

For more information circle **357** on inquiry card.

Decade Amplifier

New "Glennite F 408" decade amplifier for general laboratory use has an input cathode follower probe for versatility; features ability to insert a network between amplifier and cathode follower input; anti-microphonic construction; provision for convenient insertion of filters or padders between CF and decade amplifier section.—*Gulton Mfg. Corp., Metuchen, N. J.*



For more information circle **358** on inquiry card.

10-Mc. Lab Amplifier

New laboratory amplifier, for application in nuclear instrumentation, digital computer circuit development, and general wideband circuit problems, features front-panel-controlled options of high or low output and input impedances, continuous variable gain control, provision for external line terminations. Bandwidth from less than 1 cps. to 10 Mc.—*American Electronic Laboratories, Inc., 641 Arch St., Philadelphia 6, Pa.*

For more information circle **359** on inquiry card.

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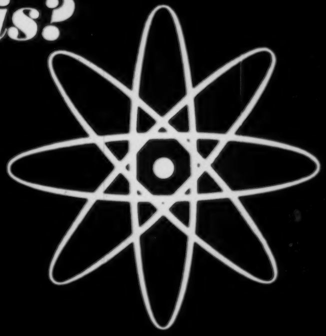

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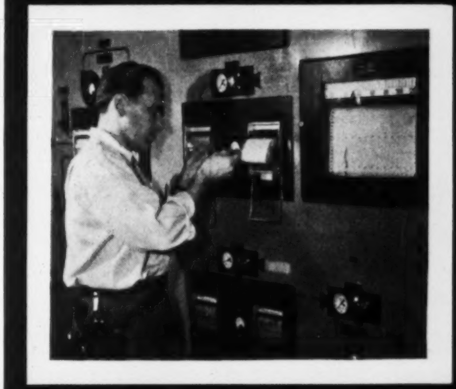

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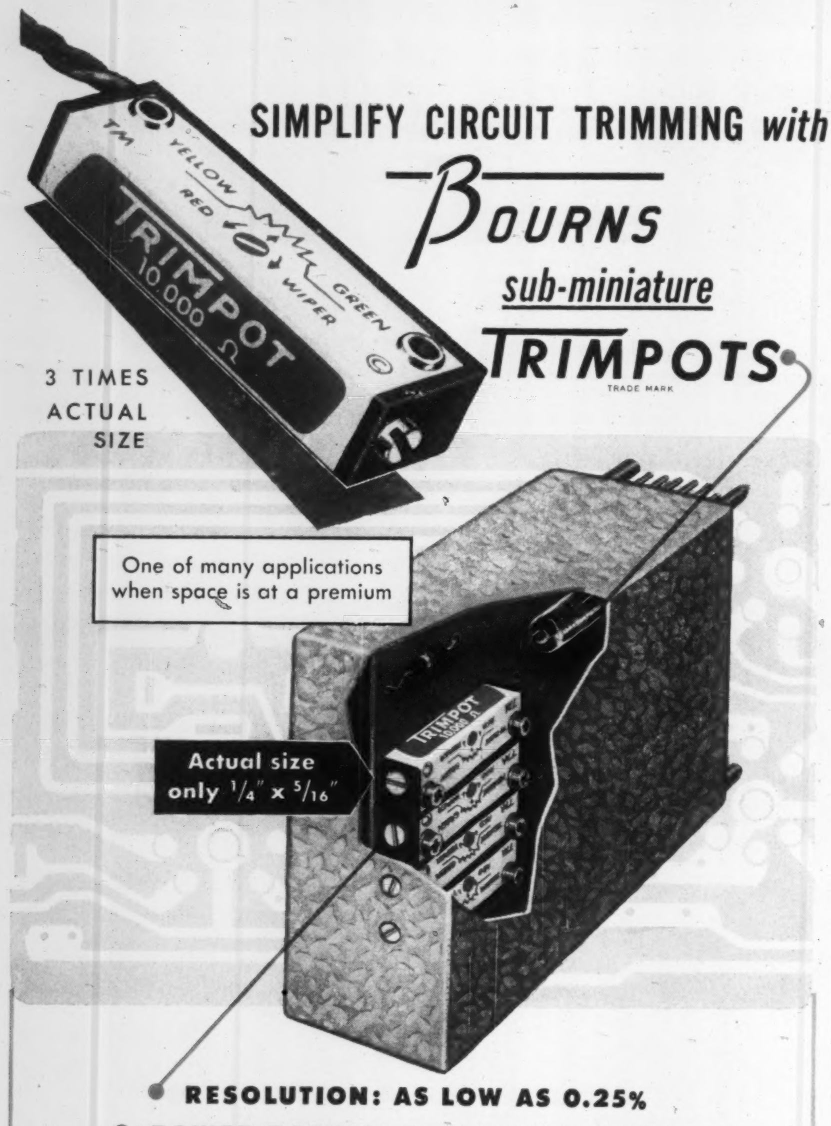
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One of many applications when space is at a premium
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- **RESOLUTION: AS LOW AS 0.25%**
- **POWER RATING: 0.25 WATT AT 100° F.**
- **WEIGHT: ONLY 0.1 OZ.**

BOURNS *TRIMPOT* is a 25 turn, fully adjustable wire-wound potentiometer, designed and manufactured exclusively by BOURNS LABORATORIES. This rugged, precision instrument, developed expressly for trimming or balancing electrical circuits in miniaturized equipment, is accepted as a standard component by aircraft and missile manufacturers and major industrial organizations.

Accurate electrical adjustments are easily made by turning the exposed slotted shaft with a screw driver. Self-locking feature of the shaft eliminates awkward lock-nuts. Electrical settings are securely maintained during vibration of 20 G's up to 2,000 cps or sustained acceleration of 100 G's. BOURNS *TRIMPOTS* may be mounted individually or in stacked assemblies with two standard screws through the body eyelets. Immediate delivery is available in standard resistance values from 10 ohms to 20,000 ohms. BOURNS *TRIMPOTS* can also be furnished with various modifications including dual outputs, special resistances and extended shafts.

BOURNS *also manufactures precision potentiometers to measure Linear Motion; Gage, Absolute, and Differential Pressure and Acceleration*

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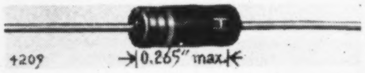
Technical Bulletin On Request, Dept. 22

For more information circle **78** on inquiry card.

ELECTRONIC COMPONENTS

Silicon Junction Diodes

New miniature silicon junction diodes have extremely high back resistance (in several types about 10,000 megohms). Hence many entirely new



circuit applications in addition to those now closed to germanium through temperature limitations.—*Semiconductor Div., Hughes Aircraft, Florence Ave. & Teale St., Culver City, Calif.*

For more information circle **360** on inquiry card.

Rectangular Resistors

Two new "Resist-O-Cards" introduce maker's new 7- and 10-watt wire-wound power resistors. Assortment #19 contains 20 values of "Type PW7," including 3300 and 3900 ohms. Assortment #20 contains 20 selected values of "Type PW10" including 3300, 3900, and 6000 ohms. Resistors are of a unique rectangular shape.—*International Resistance Co.,* 401 *N. Broad St., Philadelphia* 8, *Pa.*

For more information circle **361** on inquiry card.

Delay Line

New "Model #DL 0600-03/120" general-purpose line has a d-c, attenuation of 0.4 db for a delay of 36 usec. and rise time of 0.36 usec.; is a 120-section lumped-constant unit which can be supplied with taps every 0.3 usec. Size 13¼ x 3 x 1½ in. Temperature range –55C. to 125C.—*Epsco Inc.,* 588 *Commonwealth Ave., Boston* 15, *Mass.*

For more information circle **362** on inquiry card.

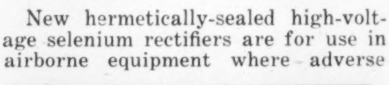
Feed-through Capacitors

New discoidal feed-through capacitors do not exhibit parallel resonance effects at frequencies of 1000 Mc. or less. This, and relatively high capacitance values with resultant low coupling impedances, make new units "ideal for UHF TV receiver applications." Improvements in filtering of more than 20 db result from their use. Capacitance values between 1000 and 2000 mmf. for all usual operating temperatures.—*Allen-Bradley Co., Milwaukee* 4, *Wis.*

For more information circle **363** on inquiry card.

Airborne-use Rectifiers

New hermetically-sealed high-voltage selenium rectifiers are for use in airborne equipment where adverse atmospheric conditions, severe vibration and rigid electrical specifications must be met. Unit pictured has

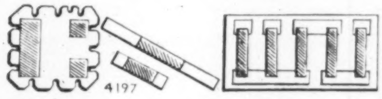


maximum a-c. input of 3300 v.rms.; output rating 1420 v.dc. and 1.5 ma. at 35 C. ambient temperature into a resistive load. At 71 C. (typical airborne ambient) 1.2 ma. at 1360 v.dc. from 2130 v.ac. input.—*International Rectifier Corp., at 1521 E. Grand Ave., El Segundo, Calif.*

For more information circle **364** on inquiry card.

Tape Resistors

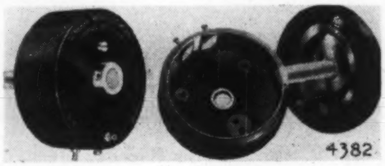
New "Type RTW" tape resistors for experimental work in building prototype assemblies of modular design have metal terminals which can be soldered to a wafer such as is used in "Project Tinkertoy," with circuit pattern fired thereon. They can be used in assemblies and tested without need of curing new resistors on a plate each time a resistor is changed.—*Hansen Electronics Co., 7117 Santa Monica Blvd., Los Angeles 46, Calif.*



For more information circle **365** on inquiry card.

Redesigned VDRs

New "970 Series" wire-wound voltage-dividing resistors comprises eight different models; power ratings from 2 to 20 watts at 40C. ambient; seventeen shock resistance values from 2 to 500,000 ohms. All high quality features have been retained but unit prices have been kept low.—*General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.*



For more information circle **366** on inquiry card.

Ultrastable Delay Line

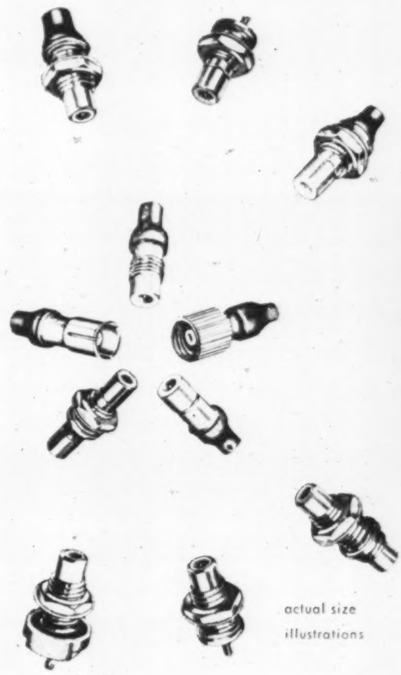
New "Model #DL0390-200LTC" has maximum over-all delay drift of less than 0.15 percent over a temperature range of –65 C. to 125 C. and under all combinations of aging and environmental conditions. Unit is a 100-section lumped constant line with an over-all delay of 200 usec. tapped every 2 usec.; rise time 6 usec. D-c. attenuation 0.12 db per section; pulse attenuation 0.14 db per section. Size 7¼ x 4⅝ x 1½ in.—*Epsco, Inc., 588 Commonwealth Ave., Boston 15, Mass.*

For more information circle **367** on inquiry card.

High-resolution VDR

New "Esipot," said to represent a completely new approach to high-resolution voltage-dividing resistors, offers equivalent of a 10-turn VDR although any setting can be made within less than two revolutions of single shaft. Assembly comprises a high-resolution single-turn VDR which actuates a ten-position attenuator switch as single-turn VDR reaches end of its travel in either direction. It can often replace a pair of controls where both "coarse" and "fine" adjustment steps are desired; also "zero adjust" control or precision gain

Circle **79** on inquiry card. →



AMPHENOL

SUB*Minax*
RF
CONNECTORS

The new AMPHENOL *Subminax RF connectors are so small that the entire line of twenty-six connectors will easily fit into the palm of your hand! Available in 50 ohm and 75 ohm impedances, Subminax connectors offer full size RF efficiency compressed into space-saving, weight-saving design.*

There are both push-on and screw-on coupling types in either 50 or 75 ohm designs. In each design there is a plug, angle plug, jack, receptacle, jack bulkhead and cable feed through. In addition, hermetically sealed receptacles are available in the 50 ohm and 75 ohm screw-on series.

CABLE ASSEMBLIES

Making Subminax cable assemblies at your plant is both easy and practical. Inexpensive and easy-to-use crimping tools have been designed by AMPHENOL *for this purpose. Subminax assemblies are also available directly from* AMPHENOL.

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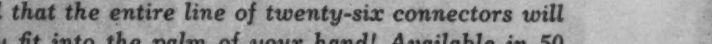

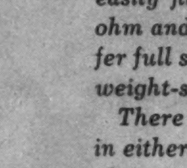

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For more information circle **80** on inquiry card.

control. Assembly is 1¾ in. in diam. by 1-¾ in. long behind panel; standard ¼ in. diam. shaft.—*Electro-Measurements, Inc.*, 4312 *S. E. Stark St., Portland* 15, *Ore.*

For more information circle **368** on inquiry card.

Tapped Delay Line

New "Model GDL.5-1K-T9" is tapped at 0.05 microsecond intervals. Hermetically sealed in epoxy. Impedance 1000 ohms; rise time 0.05 usec. Size 6¼ x ⅞ x ¾ in. exclusive of terminals.—*The Gudeman Co. of California, Inc.*, 9200 *Exposition Blvd., Los Angeles* 34, *Calif.*

For more information circle **369** on inquiry card.

Decade Delay Line

New "Model GDDL-1000-1," has over-all delay of 1 usec.; dial-selected taps at 0.1-usec. intervals; impedance 1000 ohms; over-all rise time 0.1 usec. Delay element sealed in epoxy and selectors for delay and termination have ceramic wafer switches with solid silver contacts.—*The Gudeman Co. of Calif., Inc.*, 9200 *Exposition Blvd., Los Angeles* 34, *Calif.*

For more information circle **370** on inquiry card.

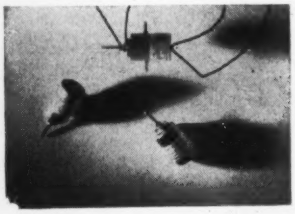
High-precision VDR

New "Model RVG-10 Potentiometer" supplements "RL" (MIT Radiation Lab) type; is smallest of this precision type: ⅝-in. diam., 7/16-in. body length, about 1½-in. total length with shaft; but is not to be confused with "trimmer pots": it has 0.1 percent resolution and 0.25 percent linearity. —*The Gamewell Co., Newton Upper Falls* 64, *Mass.*

For more information circle **371** on inquiry card.

Variable Inductors

New "Style A Type 1" variable inductors, available both shielded and unshielded, are supplied in ten standard values from 56 uh. to 1.8 mh. and up to a maximum of 25 mh. in special units; feature inductance variation range of 2:1; Q's of approx. 200; operating temperature range from –50 C. to 100 C. and temperature coefficients of inductance less than 50 ppm. per C. deg. Entire powdered carbonyl-



iron cup core and coil assembly is embedded in epoxy, whence high resistance to vibration or shock as well as good protection against moisture and chemical attack. Units can dissipate 2.5 watts with a temperature rise of 20 C.; have voltage ratings of 400 max. weigh approx. 1 oz. Also available in form of complete sealed tuned circuits with shunt capacitors included to user's specs.—*Levinthal Electronic Products, Inc., 2905 Fair Oaks Ave., Redwood City, Calif.*

For more information circle **372** on inquiry card.

Ten-turn VDR

New "1100 Series Micropot" is specifically designed for original equipment manufacturers of precision electrical devices who sell in a competitive market. Color-coded 9-in. lead wires instead of terminals permit flexibility of application and ease of installation without changing present wiring system. Rear shaft extension optional for single and ganged. Standard values 50 to 100,000 ohms. Independent linearity 0.1-0.5 percent.—*George W. Borg Corp., Janesville, Wis.*

For more information circle **373** on inquiry card.

Low-noise Cable

New "Glennite Blue Line" subminiature-size (OD 0.017 in.) coaxial cable was developed particularly for use with shock and vibration pickups; is extremely flexible and consequently not easily subject to mechanical damage; has been treated to minimize self-noise generation; has a low capacity of 38 mmfd/ft. and is usually equipped with a new subminiature coaxial screw type connector (Type C5-P). It may also be used for RF work having a characteristic impedance of 40 ohms and an insulation strength of 1200 v.dc.—*Gulton Mfg. Corp., Metuchen, N. J.*

For more information circle **374** on inquiry card.

ELECTRO-MECHANICAL

Instrumentation Motor

New "AC-93" miniature subfractional-hp. low-slip induction motor offers favorable application characteristics for instrumentation, magnetic-tape recorders, servomotors and geophysical-equipment uses; 115 v. 400 cps., 1-phase, 11,800 rpm. with 15-watt output; locked rotor torque 1.8 oz. in. minimum; maximum power input 45 watts. Rotation is reversible. Weight 14 oz.—*Dalmotor Co., 1344 Clay St., Santa Clara, Calif.*

For more information circle **375** on inquiry card.

Linear Power Unit

New "super lightweight" aircraft electrical actuator weighs 1.16 lbs. compared with 2.2 lbs. for 1953 model; is for such uses as trim tabs, artificial feel controls, etc. Normal operating load up to 150 lbs.; static load 500 lbs. tension or compression. Choice of gear ratios, jackscrews and motors. All improvements of maker's previous actuators have been retained, including non-jamming jackscrews, limit

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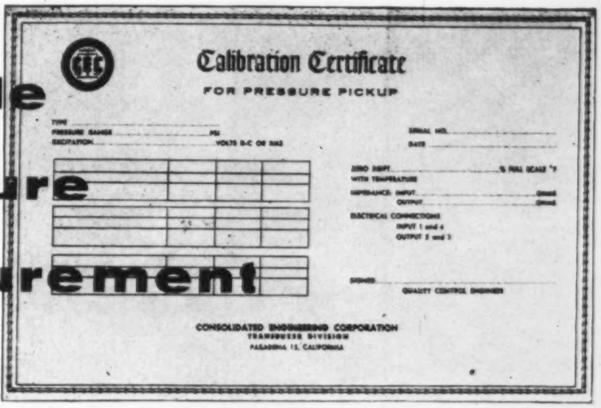

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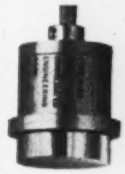

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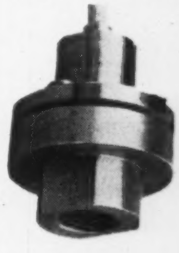

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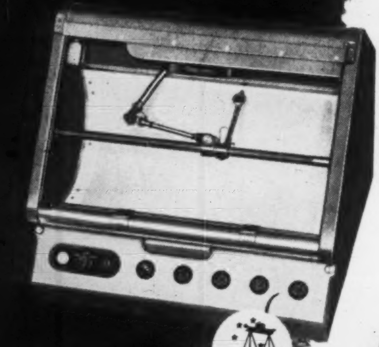

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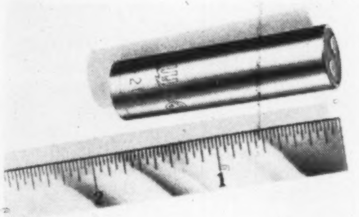
switches, built-in radio noise filters and magnetic brakes.—*AiResearch Mfg. Co., 9851 Sepulveda Blvd., Los Angeles 45, Calif.*

For more information circle **376** on inquiry card.

Miniature Solenoids

New miniature d-c. solenoids weigh as little as 1½ oz. "Model A-205" (photo) has a push-pull capacity of



9 oz. with a 1/16-in. stroke; 7½ oz. with a ⅛-in. stroke; 6 oz. with a 3/16-in stroke and 5 oz. with ¼-in. stroke; is suited for computers, etc. Mountings to meet individual specifications. —*West Coast Electrical Mfg. Corp., 233 W. 116th Place, Los Angeles 61, Calif.*

For more information circle **377** on inquiry card.

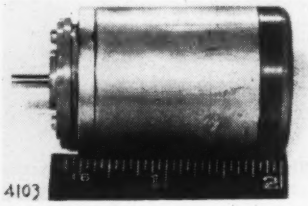
Miniature A-c. Motors

New "Type SC" subminiature 400- or 60-cps. motors, 1 1/16 in. diam., embody protection for military environments; can be wound for single-, 2-, or 3-phase; can be furnished as induction or hysteresis motors; motor can be furnished with concentric spur gear reducer.—*Globe Industries, Inc., 1784 Stanley Ave., Dayton, Ohio.*

For more information circle **378** on inquiry card.

Permanent-magnet Motor

New "Series 1200" motors, for use in aircraft actuators and servomechanisms, meet MIL-M 8609, offer up to



5 oz.-in. of torque at 60 rpm. up to 30,000 rpm.; operate on 3 to 115 v.dc.; feature specially-designed laminated field shoes used in conjunction with Alnico V magnets, 14-bar commutator armature with laminations of 7 slots with a skew of one full slot which minimizes latching effect.—*Air Equipment Co., 2248 E. 37th St., Los Angeles 58, Calif.*

For more information circle **379** on inquiry card.

Fractional-hp. Motors

New skeleton type and clutch-gear type f-hp. motors feature high starting torque, simplified mounting and low cost. Skeleton type motors are two-pole, shaded pole, sizes from 1/500 to 1/25 hp., 2100 to 3500 rpm., voltage range 6 to 220 vac. Maximum torque 14 oz-in. running and 10 oz-in. starting. Clutch-gear type motors are two-pole, shaded pole, fast disengagement time (approx. 25 milliseconds), all speeds from 4 to 328 rpm., voltage range 6 to 220 vac. At 25 rpm. torque is 100 oz-in. on continuous duty.—*Comar Electric Co., 3349 Addison St., Chicago 18, Ill.*

For more information circle **380** on inquiry card.

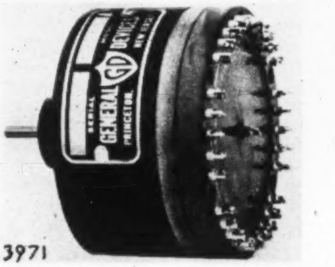
Aircraft Actuator Motor

New 400-cps. actuator motor measuring 1.705 in. OD x 2-9/16 in. long is excited with 115 v. on fixed phase and 24 v. on control phase. Torque at stall is 2.9 oz.-in. with power factor at stall torque of 50 percent. No-load speed 5100 r.p.m. Temperature range: –55 C. to 90 C. Weight 13.7 oz.—*American Electronic Mfg., Inc., 9503 West Jefferson Blvd., Culver City, Calif.*

For more information circle **381** on inquiry card.

Sampling Switch

New improved model offers increased life, exclusive wiper design, and semi-molded contact assembly. Typical specs are 60 contacts, 30 channel, 1 pole and sampling rates up to 60 rps. Multiple stacked pole designs as well as variations in number and arrangement of contacts are available.—*General Devices, Inc., P. O. Box 253, Princeton, N. J.*



3971

For more information circle **382** on inquiry card.

Remote-control Switch

New adaption of maker's standard "Bulletin 920 Remote Control Switch" is available with a control line fuse and adapter. Adapter may also be purchased as a separate item. Switches can be actuated by push buttons, timers, toggle switches, etc.—*Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.*

For more information circle **383** on inquiry card.

Overload Switch

New model of maker's "Dyna-Switch" has doubled capacity: 20,000 lbs. Accuracy of new model is within 0.5 percent; safety factor 3½ to 1, thus permitting accidental overloads

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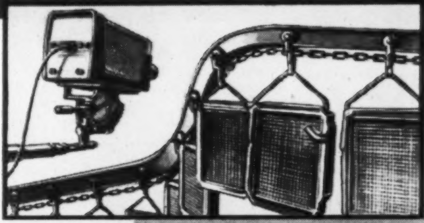

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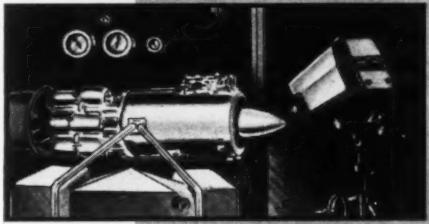

Processes which are too dangerous for direct observation may be watched safely by "UtiliVue". This includes destructive tests of machines, tests of explosives, atomic operations, etc.

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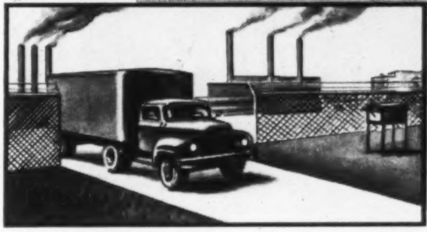

"UtiliVue" cameras are available in weatherproof housings which enable one guard to watch several entrances at the same time. This is particularly useful for remote, infrequently used entrances.

Many plants have "watching and waiting" jobs scattered around . . . jobs where a man doesn't do anything except watch an operation and report at intervals to a person elsewhere.

The Diamond "UtiliVue" (wired television) can do the watching and waiting, releasing manpower for more productive work. It will watch any process . . . no matter how remote, dangerous or inaccessible . . . and bring a clear image to the observer. It enables him to SEE simultaneously and to coordinate several scattered but related jobs . . . an advantage obtainable in no other way. There can be no mistakes in communications. Get all the facts. Get in touch with your Graybar Distributor or use the coupon below.

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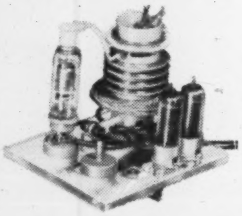

This compact, well designed, ruggedly built DC supply utilizes two 6AQ5 tubes as a parallel oscillator feeding a 1X2 rectifier tube. For an output voltage of 4½ KV DC at 1 milliampere, the low voltage input requirement is 250 V at 50 milliamperes. By varying the DC input the output voltage can be varied from approx. 1 KV to 7½ KV. Dimensions: 5⅝" high x 5" deep x 4¼" wide. In completely enclosed metal housing (not shown). Less low voltage DC supply **$32.50 Net**

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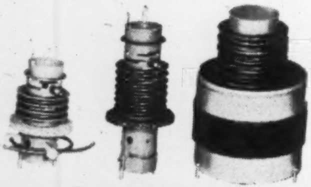

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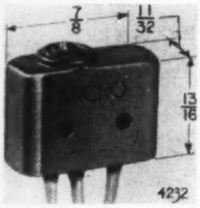
NEW INSTRUMENTS

up to 70,000 lbs. without damage to calibration. For 110 or 220/440-volt supply.—*W. C. Dillon & Co., Inc., P. O. Box 3008, Van Nuys, Calif.*

For more information circle **384** on inquiry card.

Environment-proof Switch



New "ISEI," said to be "the smallest and lightest sealed precision snap-acting switch available," operates from –65 to 180 F. Mechanical life expectancy 300,000 operations.—*Micro Switch, Freeport, Ill.*

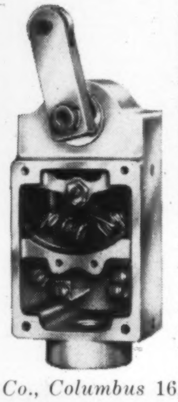
For more information circle **385** on inquiry card.

Stepping Switch

New stepping switch for heavy-duty operation extending beyond 100-million steps (impulse or self-drive) has a speed of stepping of 60 or 68 steps per second, depending on wiper arrangement. Armature stroke is set by a simple adjustment of knife-edge suspension, in full view of front. Interrupter springset is adjusted by setting camber of base-plate by means of two securing screws. Standard coils 22, 40, 50, and 60 v.dc.; specials for other voltages.—*Imtra Corp., 58 Charles St., Cambridge 41, Mass.*

For more information circle **386** on inquiry card.

Machine Tool Switch

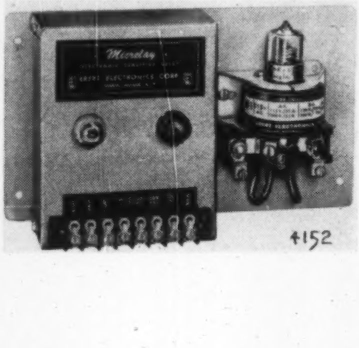


New "Model L-100S" features snap action. Design has repeatedly withstood 25,000,000 actuations. Silver contact points are reversible. Terminal compartment is separate from switch compartment. Various actuators available; roller and pin in standard actuator are made of hardened steel; 70 deg. overtravel. Rating 25 amps, 125 volts ac-dc.—*Acro Mfg. Co., Columbus 16, Ohio.*

For more information circle **387** on inquiry card.

Control Relay

New "Micrelay" controls loads up to 60 amps. or 3 hp. from extremely low power devices such as photocells. It is completely a-c. operated, using one commercial long-life Type 2D21 min-



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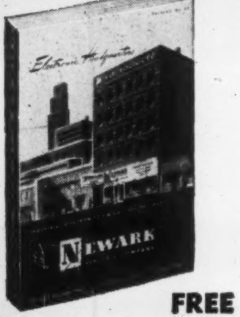

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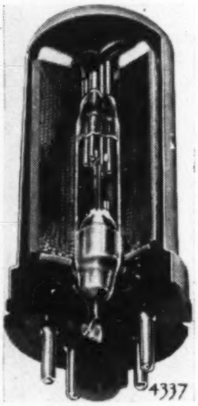
iature thyratron and maker's "Mercury Plunger Relay" (UL approved). It supplies its own operating voltages for high and low impedance applications, suitable for control circuit impedances from 10 megohms to 100,000 ohms; may also be operated from an external 9 v.ac. or 12.5 v.dc. signal of source impedance up to 10 megohms. —*Ebert Electronics Corp., 212-23C Jamaica Avenue, Queens Village 28, N. Y.*

For more information circle **388** on inquiry card.

Mercury-type Relays

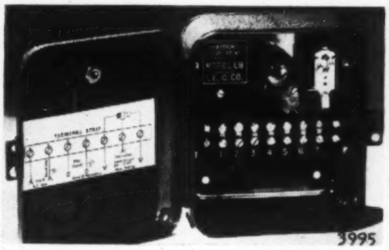


New "Types HG and HGP" mercury-wetted contact relays, said to be capable of over a billion operations without maintenance, are designed for use in high-speed switching machines and devices; operate at up to 60 operations a second; have high current-carrying capacity (up to 5 amps.), high voltage-handling capacity (up to 500 volts); are bounce- and chatter-free.—*C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.*

For more information circle **389** on inquiry card.

Control Relay

New "Model EB Electronic Pilot Relay" can control 5 amps. at 115 v.ac.; draws 2 microamps maximum from master measuring instrument; features a cold-cathode tube (no warm-up).—*Industrial Electronic Controls Co., 2271 E. 14th St., Brooklyn 29, N. Y.*



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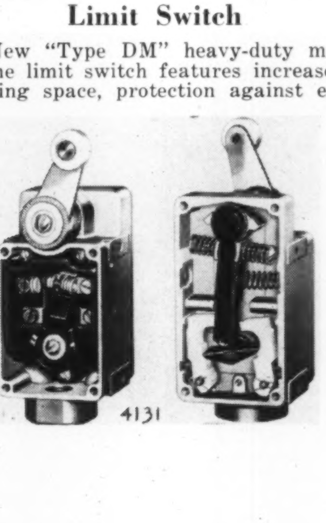
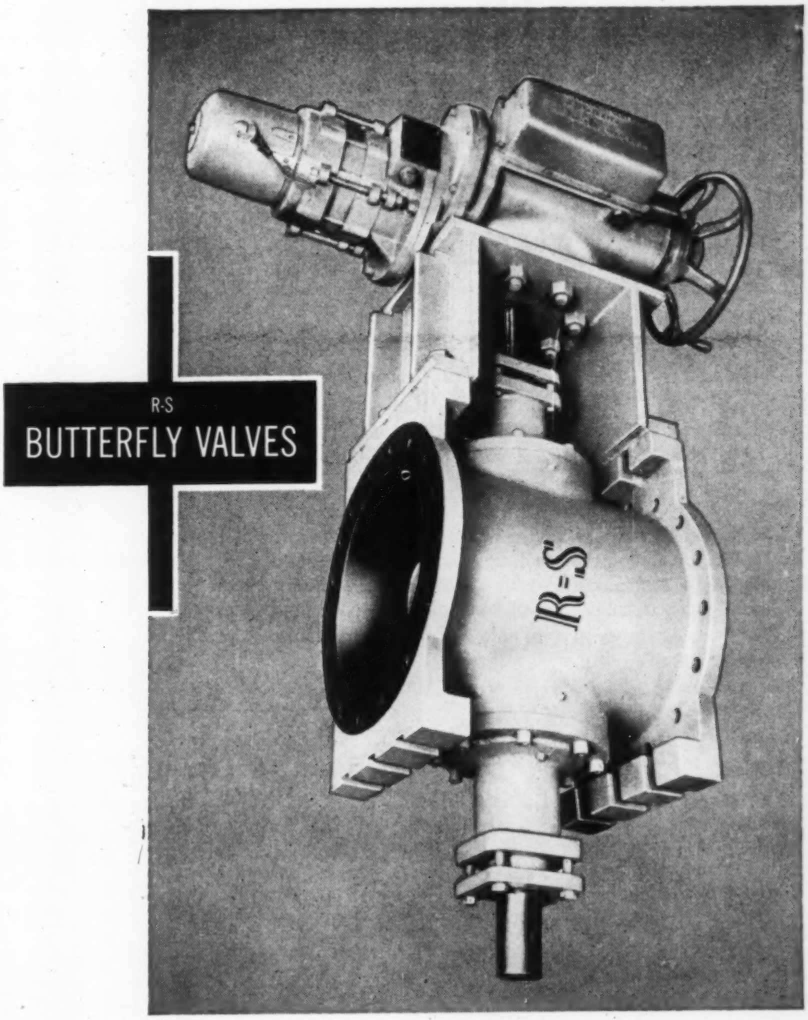
Limit Switch

New "Type DM" heavy-duty machine limit switch features increased wiring space, protection against ex-





SPECIAL R-S VALVES RESIST CORROSION...ABRASION...HEAT

Where rugged processing conditions call for special handling, R-S Butterfly Valves are designed and built to meet individual requirements. Any type of metal or other material that can be cast or welded—even plastics—may be specified for valve bodies or parts.

Special metals have been developed to withstand corrosion, abrasion, erosion, high heat and pressure. For certain types of corrosion, the R-S Rubber-lined Valve may be used. Every R-S Valve gives you the advantages of quick and positive closure with any type of controls, uniform control in normal regulating range, and minimum pressure drop to save power.

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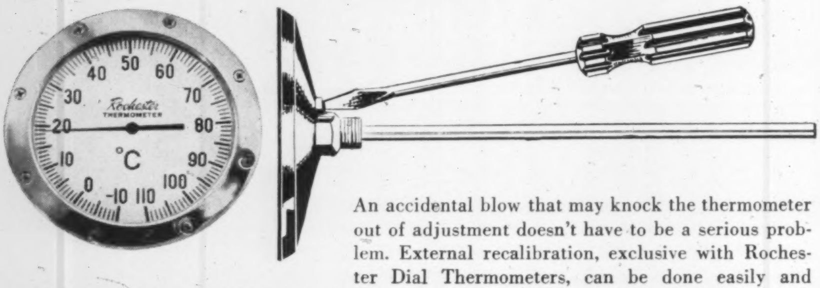

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An accidental blow that may knock the thermometer out of adjustment doesn't have to be a serious problem. External recalibration, exclusive with Rochester Dial Thermometers, can be done easily and quickly. Insert the stainless steel stem in any liquid of known temperature and adjust the dial with the set screw attachment. It's done easily and quickly, EXTERNALLY, and is completely accurate.

Other plus features include:

All parts, except the crystal, are of corrosion-resistant stainless steel.
Hermetically sealed against moisture and grime.
All readings are completely legible and accurate.
Precision bi-metal helices precalibrated to dial before assembly.
Stem position can be located anywhere around circumference of the dial in the STRAIGHT form thermometers.

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First Aid for the sound engineer — the ACA Flutter Meter! Accurate, sensitive instrument designed for rapid visual indication of flutter, wow, and drift content of discs (all speeds), sound film mechanisms, film recorders, and magnetic wire and tape recorders.

Three distinct and simultaneous readings may be made of flutter, wow, and drift. Large, sensitive 4" meter has three scales: 0.3%, 1.0%, and 3.0%, calibrated for flutter, wow, and drift readings. Accuracy within 2% of full scale value, independent of wave-form, amplitude variation, hum, noise, etc.

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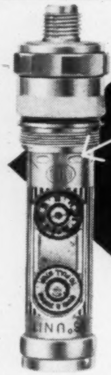

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For more information circle **92** on inquiry card.

cessive overtravel achieved without shear pins, complete separation of electrical and mechanical mechanisms, and nylon-to-steel wearing surfaces. Rating 10 amps. continuous, to 600 v.ac.—*Clark Controller Co., 1146 East 152nd St., Cleveland 10, Ohio.*

For more information circle **391** on inquiry card.

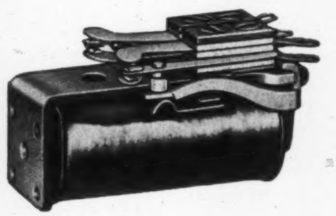
6-p.d-t. Relay

New "Series 2005" is a 6-pole double-throw hermetically-sealed 5-amp. subminiature unit said to be "years ahead of modern design trends." Meets MIL-R-6106-A, Class A, and MIL-R-5757-B, Class A; withstands 100 *G* shock, and 10 *G* vibration from 75 to 2000 cps. in all mounting planes. —*Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill.*

For more information circle **392** on inquiry card.

Telephone-type Relay

New "SQ" miniature single-coil telephone relay is available in 1 to 5 amps. contact ratings, and in contact combinations from spst. to 6-pdt.; maximum sensitivity of 15 mw. per pole in dpdt. combination withstanding 10 *G* vibration from 10 to 500 cps. (with 40 mw. per pole, 30 *G*). Dpdt. units are available also in a sealed container, solder-terminal or plug-in.—*Advance Electric & Relay Co., 2435 N. Naomi St., Burbank, Calif.*



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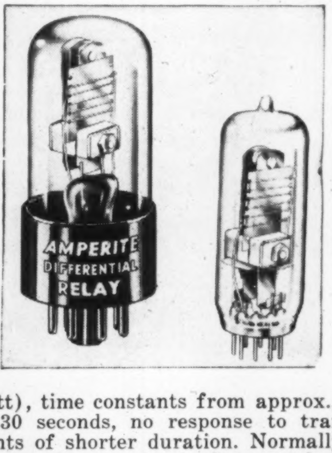
Protective Relays

New differential relays can be used for automatic overload, over-voltage, under-voltage or under-current protection. They reset automatically when abnormal condition is removed. Actuating element is a heater (approx. 1 watt), time constants from approx. 3 to 30 seconds, no response to transients of shorter duration. Normally-open or closed contacts. Currents from



10 to 1000 ma.; voltages from 1 to 100.—*Amperite Co., 561 Broadway, New York 12, N. Y.*
For more information circle **394** on inquiry card.

High-voltage Connectors

New "PM6/HV" six-contact connector features one-piece molded mineral-filled Melamine insert bodies designed to fit standard AN 20 shells. Plug and receptacle halves can be supplied assembled in any of 3100 to 3108 solid or split shells required. Contacts are rated at 5 amps. Voltage breakdown at sea level 6800 v.dc.; at 60,000 ft. 1400 v.dc.—*Winchester Electronics, Inc., Norwalk, Conn.*
For more information circle **395** on inquiry card.

Explosive Disconnect

New explosive disconnect plug and receptacle provides for instantaneous opening of as many as 100 circuits on a non-shorting basis. Where desired, time delay up to 3 seconds can be incorporated. Two primers (visible at opposite sides of illustrated unit) are fired and two securing screws (one visible, front) are severed.—*Beckman & Whitley, Inc., 930 E. San Carlos Ave., San Carlos, Calif.*
For more information circle **396** on inquiry card.

TUBE FITTINGS

Black Finish Fittings

New steel "Ferulok" tube fittings are now being produced with Parker "Lubrite" finish, a permanent black coating in contrast to former bright plating of steel "Ferulok." Major advantage is lubricating quality, minimizing wrench torque required to make-up fitting and providing easy reassembly of joint without use of oil.—*Parker Appliance Co., Cleveland 12, Ohio.*
For more information circle **397** on inquiry card.

Quick Hose Couplings

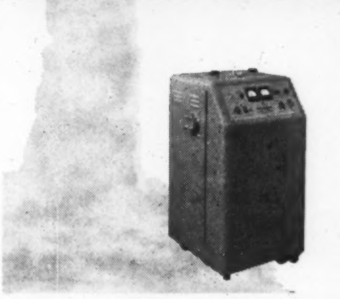
New "Pushomatic" quick connect and disconnect couplings for air and hydraulic hose feature one-hand operation without turning or twisting

positive leak tightness for **split-second action**

Is your product inactive for prolonged periods, then called upon for *immediate* action? That's the problem facing Schwien, Inc., makers of gyros for guided-missile flight control.

To make sure their gyros will deliver on demand anytime, at any altitude, Schwien uses three CEC Mass Spectrometer Leak Detectors. Each and every sealed gyro is pumped out . . . filled with dry, inert gas . . . then checked *twice* with this phenomenally sensitive quality-control tool. Leaks so small that they pass only *4×10^{-7} std cc per second*—undetectable by any other method—are pinpointed unfailingly.

With this important assist from CEC mass spectrometry, Schwien *knows* that their product can sit for years . . . then, thanks to proved leak tightness, spring into action in a split second.



TWO CEC LEAK DETECTORS
Schwien uses standard 24-101A instruments, which can measure leak rates to 10^{-9} std cc/sec . . . detect 1 part helium in 200,000 parts of air. For *ultra-critical* atomic and electron-tube work, the new Type 24-110 detects 1 part helium in *2,000,000 parts of air.* Both instruments are described in CEC Bulletin 1801D-X6.

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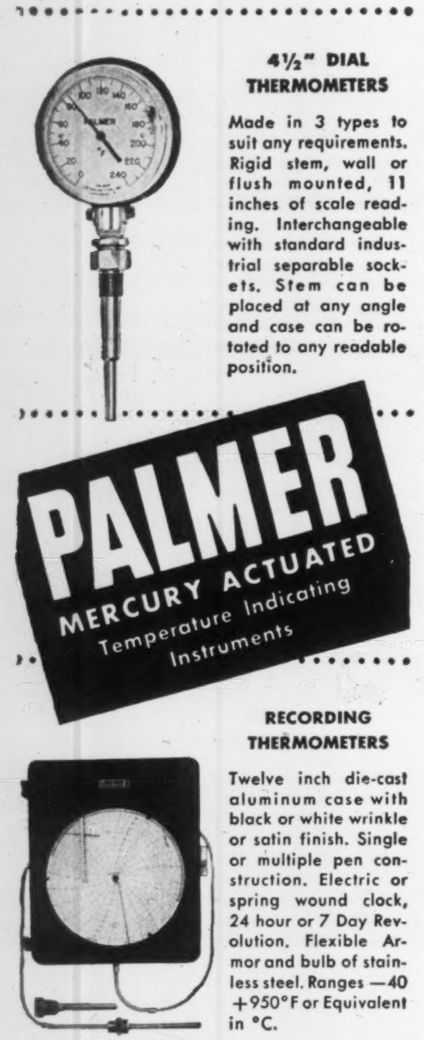

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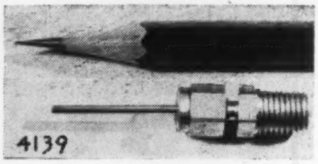
For more information circle **94** on inquiry card.

to lock. Integral check valve shuts off pressure when disconnected. Sizes ⅛-in. through ¾-in. Application up to 10,000 psi.—*Breco Div. Perfecting Service Co., 332 Atando Ave., Charlotte 6, N. C.*

For more information circle **398** on inquiry card.

Small-tube Fitting

New "1/16 in. Capillary Swagelok Tube Fitting" does away with small-size tube problems. No special tools required, nor any preparatory work on tube. Available in brass, aluminum, steel, stainless steel and Monel.—*Crawford Fitting Co., 884 E. 140th Street, Cleveland 10, Ohio.*



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VALVES

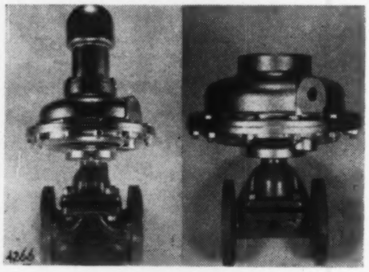
Bulk Loading Valve

New "Bulletin 8023 Solenoid Valve," combining electrical control and manual operation, for controlling flow of gasoline, kerosene, diesel and fuel oils in remote metering systems, is designed to provide terminal dispatcher with complete and absolute control of all deliveries. Electrical interlock prevents withdrawal until authorized by dispatcher; unregistered deliveries are eliminated.—*Automatic Switch Co., Orange, N. J.*

For more information circle **400** on inquiry card.

Saunders Valves

New line of "Air Operated Saunders Patent Type Valve" comprises sizes ½-in. through 4-in., flanged and screwed, spring type and springless, air-to-open and air-to-close, in wide choice of body materials, and with linings of rubber, neoprene, saran, hard rubber, glass, etc.—*Uniflow Valve Corp., P. O. Box 171, Linden, N. J.*



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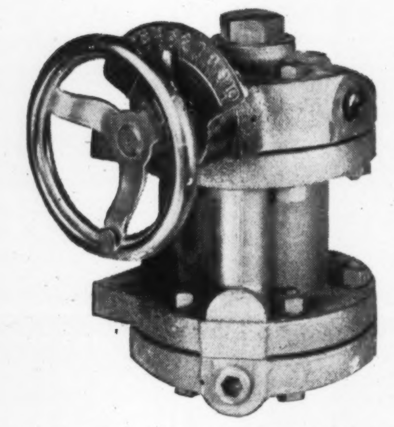
Constant-flow Valves

New constant-flow valves maintain rate of flow within one percent up to 200, 300, 400, 500, 600, or 700 gph.; each model will maintain flow as low as 10 percent of maximum. Fluids can be fuel oil or other non-abrasive liquids with viscosities as high as 250 ssu. at static pressures to 500 psi. and temperatures to 250 F., despite fluctuations in upstream or downstream pressure. Flow is accurately maintained as long as fluid viscosity and temperature are constant and pressure differential across valve is 40 psi. or higher for maximum flow.—*Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.*



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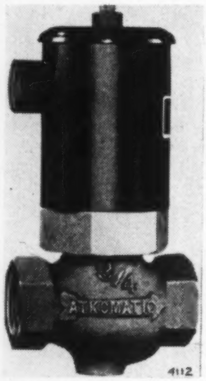
Solenoid Valves

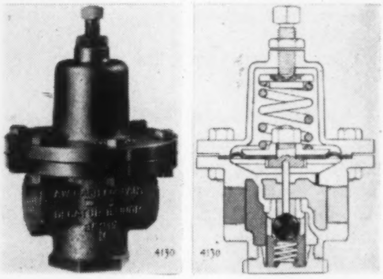


New general-purpose semidirect-lift solenoid valves are normally-closed (when de-energized); packless; full-ported; suitable for use with media not harmful to bronze or 316 or 416 stainless steel. Sizes ½, ¾ and 1 in. pipe.—*Atkomatic Valve Co., 545 Abbott St., Indianapolis, Ind.*

For more information circle **403** on inquiry card.

Pressure-regulating Valve

New "Standard Type 1260" features extremely low pressure drop and lock-up, operates within a range of 300 psi. inlet pressure and 3 to 250 psi. delivered pressure; is said to combine minimum size and weight with greater sensitivity. Low pressure drop is achieved through use of Venturi principle. Other features: free rotation of self-cleaning ball inner valve; new large-area built-in strainer.—*A. W. Cash Co., P. O. Box 551, Decatur, Illinois.*



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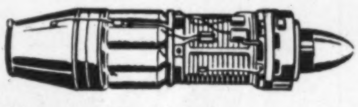
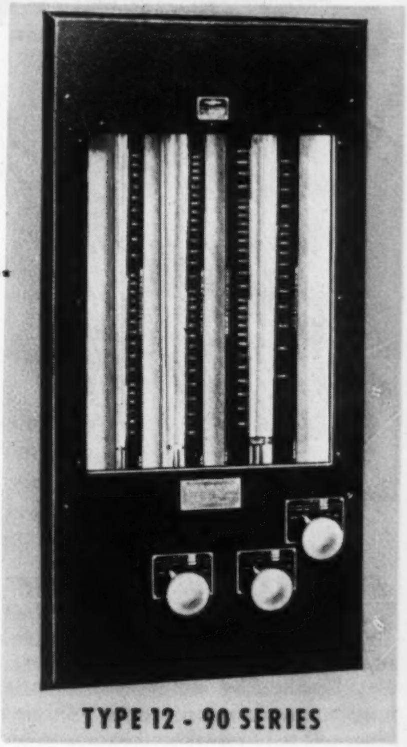
BEFORE THIS JET CAN *FLY*



ITS INTRICATE FUEL SYSTEM MUST "*FLOW*"

AND THAT MEANS

COX *Multiple Stage type 12* FLOWMETERS

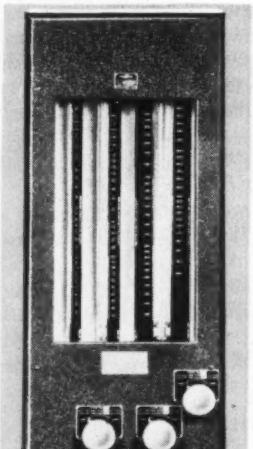


TYPE 12 - 90 SERIES

Ever stop to wonder why Cox Multiple Stage Type 12 Flowmeters are so widely used by the U. S. Airforce and U. S. Navy?

The answer is that both these services must know *exactly* how much fuel a plane's fuel pumps and fuel nozzles can handle in a given amount of time—in order to determine the operating reliability of its intricate fuel system. In jets, particularly, accurate flow rate testing is essential, since the fuel system must be capable of pumping and carrying tremendous amounts of fuel each minute the plane is in the air.

Experience has shown America's major users of precision flowmeters that the Cox Type 12 can always be depended upon for *first-rate performance.* Its record of service is unmatched in providing accurate, dependable testing of jet nozzles, fuel pumps, carburetors, and other items forming the vital "flow systems" of jet and reciprocating engines.



TYPE 12 - 100 SERIES

The Cox Multiple Stage Type 12 is available in three series—the 40, the 90, and the 100. All possess remarkable accuracy, repeatability and quick response. Maximum capacity of the *40 Series* and the *90 Series* is 36,000 pounds per hour. *The 100 Series* provides a maximum flow capacity of 32,500 pounds per hour. Use of a bypass orifice greatly increases the flow capacity of each instrument without increasing its frontal area.

Readings to the nearest graduation on individually graduated logarithmic type scales are normally within ½% to 1% of the indicated flow, depending on the particular series. Flowmeters are calibrated for a specific fluid and scales for metering liquids of different characteristics can be easily interchanged.

Patented "Inner Wall" guides, integral with the metering tube, assure a true flow pattern by keeping the float centered in the tube at all times.

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For more information circle **95** on inquiry card.

Industrial uses of ANALOG COMPUTERS

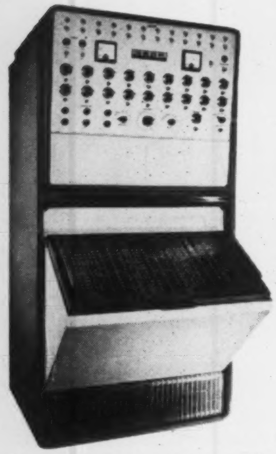
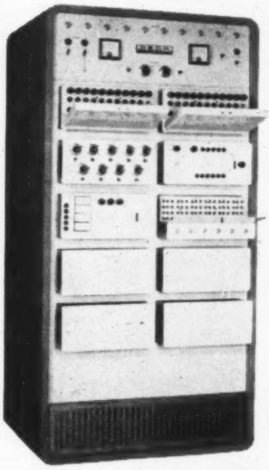


Fig. 1. GEDA L-3 linear computer.



GEDA N-3 nonlinear computer.

R. L. HOVIOUS, C. D. MORRILL, and **N. P. TOMLINSON**

Goodyear Aircraft Corporation

GENERAL-PURPOSE ANALOG COMPUTER (or electronic differential analyzer) is a device for rapid analysis of equations or functions that represent physical systems. The system to be analyzed is simulated either by differential equations or by transfer functions, which then are analyzed by the computer. Computers (Fig. 1) contain electronic and electromechanical computing elements arranged for convenient interconnection.

The computer makes it possible to set up and study complicated equipments and systems. It provides quick answers to engineering problems, and furnishes insight into and an understanding of such problems. The basic philosophy of such a device is that analogous systems act in the same ways and satisfy the same type of mathematical relations. These relations may be either linear or nonlinear. (A linear device is one for which the ratio of output variable to input variable is independent of the amplitude of the input variable; the output-input ratio of nonlinear devices depends on the amplitude of the input variable. Thus, saturation, backlash, deadspace, multiplication of variables, etc., are nonlinearities.)

The use of nonlinear equipment (multipliers, function generators, limiters, and special circuits) greatly expands the versatility of the analog technique because many typical systems have nonlinear elements such as backlash and deadspace. A general-purpose electronic differential analyzer capable of analyzing the performance of nonlinear systems is of particularly high value because analytical methods for solution of nonlinear systems are difficult.

In order to analyze a system by use of an analog computer, the system must be represented either by equations or by transfer functions. The latter are particularly important for unit chemical processes, heat-transfer devices, and other equipments that can not be described easily in equation form.

Transfer Functions

A transfer function is an expression relating the output of a device in terms of its input. It is simply the ratio output/input, and can be considered as the "blackbox" representation of an element in terms of its response to a unit change in input. To simulate a chemical process for analysis by the computer, the transfer functions of every element in the system can be found simply by imposing unit disturbances on the element and recording the output, analysis of which gives the transfer function. Use of this technique permits most systems to be prepared rapidly for analog-computer analysis—without use of any difficult equations, as will be described.

Basic Computer Operations

The four basic operations in analog simulation of a system are (1) multiplication, (2) addition, (3) integration, and (4) differentiation.

The basic element in most electronic differential analyzers is the *direct-coupled amplifier*. With various feedback elements, the unit d-c amplifier becomes either a multiplier, a summing element, a differentiator, or an integrator.

Operational Amplifier as Sign Changer

Fig. 2 shows how two resistors are used with the amplifier to produce a sign changer, or inverter (a circuit that

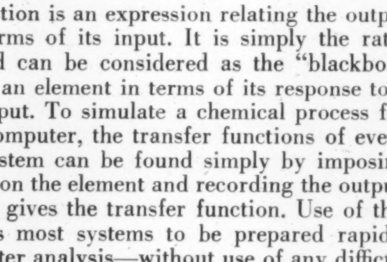


Fig. 2. Operational amplifier as sign changer, or inventer. Point A, where input resistor and feedback resistor meet, is called summing point, or virtual ground (because it remains at ground potential within a few microvolts).

Presented at the Computer Clinic, First Automation Exposition, New York, N. Y., Nov. 30-Dec. 2, 1954.

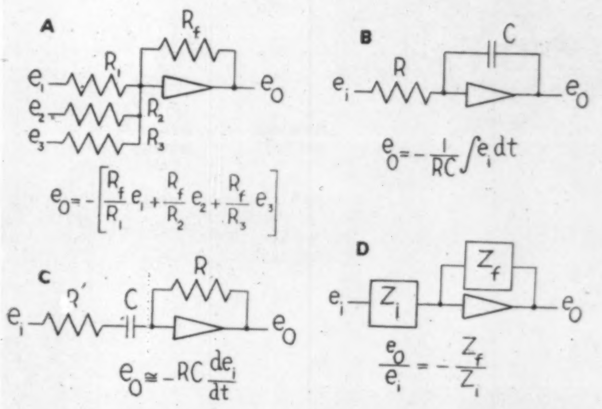

A
R_f
R_1
e_1
e_2
e_3
R_2
R_3
e_0
$e_0 = -\left[\frac{R_f}{R_1}e_1 + \frac{R_f}{R_2}e_2 + \frac{R_f}{R_3}e_3\right]$
B
C
R
e_i
e_0
$e_0 = -\frac{1}{RC}\int e_i\,dt$
C
R
C
e_i
e_0
$e_0 \cong -RC\frac{de_i}{dt}$
D
Z_f
Z_i
e_i
e_0
$\frac{e_0}{e_i} = -\frac{Z_f}{Z_i}$

Fig. 3. Various feedback arrangements convert the operational amplifier (shown as triangle) into (A) summing amplifier, (B) integrator, (C) differentiator, or (D) generalized circuit.

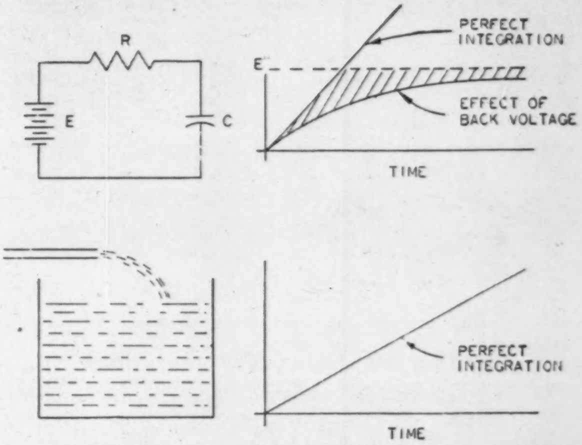


Fig. 4. Exponential rise in capacitor voltage limits usefulness of conventional RC integrator. Use of operational amplifier and feedback (as in Fig. 3,B) eliminates effect of capacitor back voltage and produces a near-perfect integrator.

A revolution is in the making. Simulation technique can put a working, adjustable model of a complex system in the hands of the plant or instrument engineer—and only empirical transfer-function-type equations for the equipment are required. Here is a complete and basic introduction to this new technique.

multiplies the input by –1). A triangle is the conventional symbol for an operational amplifier.

In Fig. 2, E_i is the input voltage; E_o the output; R_i the input resistor; R_f the feedback resistor; gain of the amplifier is 30 million; amplifier draws no grid current.

The maximum output voltage is 100 volts. Therefore, the voltage at the summing point (point A) must *always be less than* 3.3 *microvolts. This can be considered zero* for computing the current I_i in the input resistor.

As point A is effectively at zero potential (within 3.3 uv), the current in the input resistor (I_i) is E_i/R_i; similarly, current in the feedback resistor (I_f) is E_o/R_f. As there is zero grid current to amplifier, the current in the input resistor must equal current in the feedback resistor, or $I_i = I_f$.

Thus, if R_i equals R_f, then $E_o = -E_i$.

Point A is called the virtual ground because it never departs from zero potential by more than a few microvolts. It is important to understand this basic feedback circuit because it illustrates the principle by which various operations are performed with the operational amplifier.

This use of total feedback around such a high-gain amplifier is a dramatic illustration of the entire feedback concept, about which so much is written. When the two resistors in Fig. 2 are equal, point A, the virtual ground, does not depart from zero potential by 1 part in 3 million; yet the output is a perfect inverse of the input signal.

When a capacitor is used as the feedback path (Fig. 3), the summing point again remains at near-zero potential; yet the output becomes a near-perfect integral of the input signal.

D-c Amplifier as Integrator

Electronic integrators are used more than differentiators because the former are less sensitive to noise. Differentiators have larger outputs for high-frequency signals and, therefore, emphasize high-frequency noise impulses. Integrators, however, have smaller outputs for high-frequency signals and thus effectively reduce noise effects.

Electronic integrators are based on the charging of a capacitor (Fig. 4). The voltage across the capacitor builds up like the volume of liquid in the storage tank—that is, the volume (or voltage) is proportional to the time integral of the flow. However, the back voltage across the capacitor in the RC integrator produces an exponential rather than a linear rise in voltage. This limits the use of the simple RC circuit as an integrator to the small initial rise that is fairly linear.

The back-voltage effect of the capacitor can be overcome by introducing a voltage source whose voltage is equal to, but whose polarity is opposite to, that of the capacitor voltage. This eliminates the effect of the back voltage and produces a near-perfect integrator.

In practice, a high-gain amplifier (shown as a triangle in Fig. 3) is used to develop the compensating voltage. The circuit then becomes a near-perfect integrator.

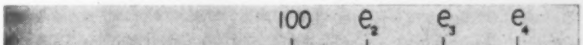


Fig. 5. Analog computer uses two types of multiplier—the servomultiplier and the electronic multiplier. In the servomultiplier the voltage e_1 controls a servo motor which positions all the ganged "pots" simultaneously.

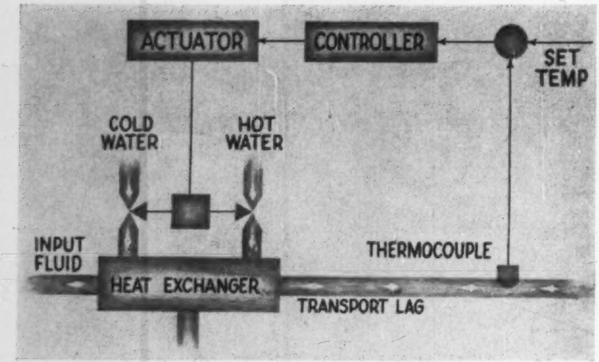


Fig. 6. Typical process-control problem.

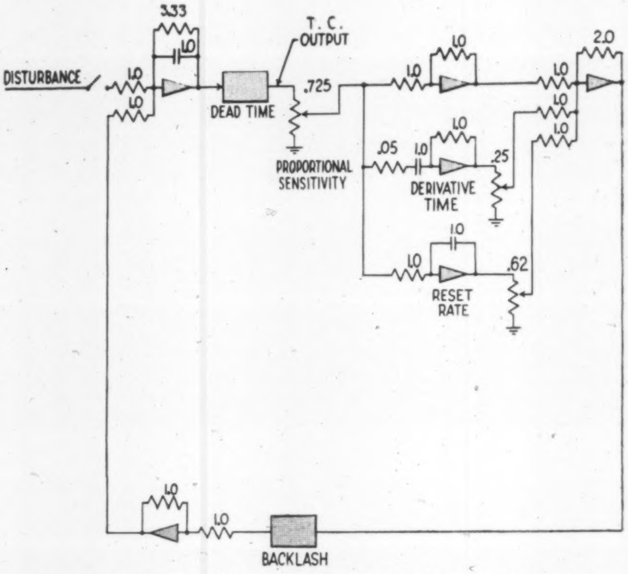


Fig. 7. Computer circuit for the process-control problem of Fig. 6. All elements in the physical system are simulated and ready for computer analysis.

D-c Amplifier as Adder, Differentiator, Etc.

The d-c amplifier can be used as an electronic adder or as an electronic differentiator with the feedback circuits shown in Fig. 3. With resistive feedback, the output is a function of the sum of the several inputs; with R-C input and resistive feedback, the output is a function of the rate of change of input, and hence the circuit is a basic differentiator.

Note that a d-c amplifier with resistive input and resistive feedback is a coefficient multiplier, with the output equal to the input voltage times the factor R_f/R_1.

Fig. 3 shows the basic computing circuits built around the d-c amplifiers. Each circuit can be readily and quickly set up in the computer by insertion of a few patch cords into the appropriate holes in a patch panel. The final illustration in Fig. 3 shows that the basic equation used to determine the input and feedback impedances for obtaining any desired response is $e_o/e_i = -Z_f/Z_i$.

Multiplication

Two types of multiplying devices are used in analog computers. One is the electronic multiplier; the other is an electromechanical multiplier (Fig. 5).

The electromechanical multiplier is a variable-gain device consisting of servo-driven and mechanically-ganged potentiometers which are positioned in accordance with the d-c input voltage. The servomultiplier, although accurate, limits the range of operating frequencies because of the dynamics of the servomechanism components. The all-electronic multiplier responds to higher input frequencies than the electromechanical type. The output voltage is proportional to the product of the two input variables and obeys the algebraic law of signs.

Process Control Application

The application of the analog computer to a process controller is shown in Fig. 6. It is desired to control the temperature of a fluid involved in a process at a point remote from the origin of the material. This is done by heating and cooling the fluid by means of a heat exchanger around the fluid's pipeline which, due to space problems, must be located near the origin of the fluid.

The temperature of the fluid is sensed by a thermocouple located at the point where the temperature must be controlled (the entrance to another phase of the process). The thermocouple output voltage is compared with the desired reference, and the temperature error signal is the input to a controller which modifies the signal. For accurate control it is necessary to use the three basic controller responses—proportional, derivative, and reset. These three signals are summed and the total signal is amplified in order to position (by a solenoid device) the spool of a pneumatic pilot valve. Pressure from this pilot

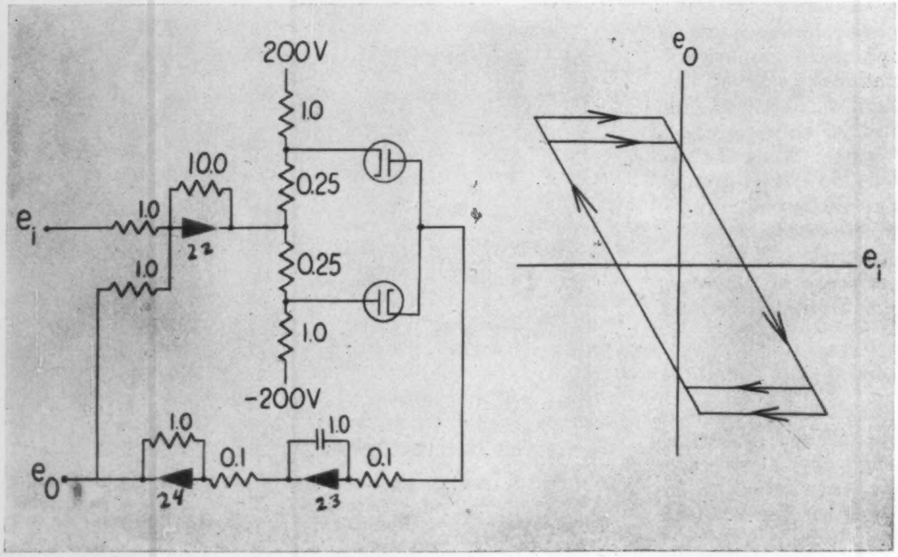
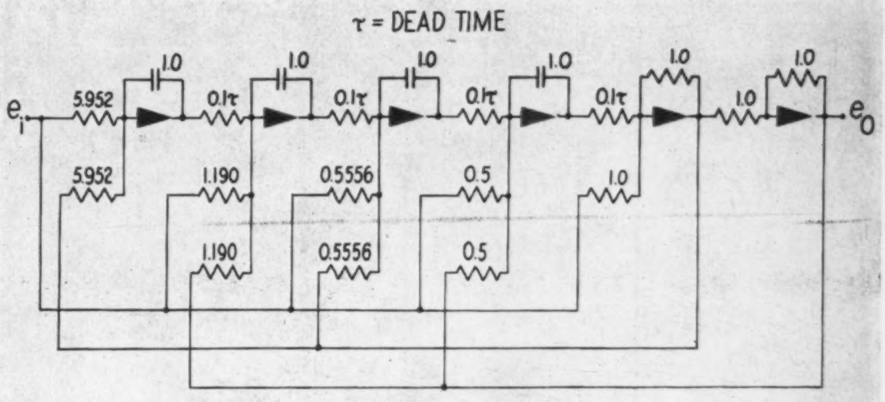


Fig. 8. Backlash in the actuator is simulated by this computer circuit. This basic backlash circuit is now available and can be used to simulate hysteresis, backlash, etc., in any process application.



$$\frac{e_0}{e_i} = \frac{1680 - 840\tau s + 180\tau^2 s^2 - 20\tau^3 s^3 + \tau^4 s^4}{1680 + 840\tau s + 180\tau^2 s^2 + 20\tau^3 s^3 + \tau^4 s^4} \cong e^{-\tau s}$$

Fig. 9. Dead time (transport delay) in the process is simulated by this computer circuit, which is now available for any such application.

system actuates a pneumatic diaphragm motor (the actuator), which injects a mixture of hot and cold water into the jacket of the heat exchanger. If the fluid flowing past the thermocouple is too hot, the actuator causes a cooler mixture to be injected into the heat exchanger; if the thermocouple reads low, a hotter mixture is injected.

Time Lags in System

It is known that the valve exhibits a backlash characteristic due to stem friction. This hysteresis corresponded to about 1 percent of full stem travel. Due to time required for heat transfer, diffusion, etc., a simple time lag of about 3.3 seconds was experienced in the heat exchanger. An additional time was required for the process fluid to flow down the line to the thermocouple. This pure dead time, or transport delay time, was 1 second.

A rough preliminary analysis of the system was made quickly (neglecting nonlinearities and time delays) for the purpose of setting controller gains, etc. From these considerations we pass to the computer wiring diagram (Fig. 7).

Let us start at any convenient point in the system, say the thermocouple (marked T.C. OUTPUT at top of Fig. 7). Proceeding clockwise, the first circuit encountered is that for the controller. The proportional signal is computed by the top branch, the derivative signal by the middle branch, and the reset signal by the bottom branch. All three signals go to the summer amplifier because the controller adds the signals. The output of this amplifier is the pilot valve signal; because the pilot valve dynamics can be ignored, it also represents the pressure signal to the diaphragm motor.

The next circuit encountered simulates the effect of backlash, or hysteresis, in the diaphragm-motor valve; this is shown as a block in Fig. 7 marked "backlash." The output of the backlash circuit is the change in temperature of the water *to* the heat exchanger. Coming on around, an amplifier is encountered which represents the time delay *in* the heat exchanger. The final circuit (a block marked "dead time") represents the transport delay, or dead time, of 1 second. The output of this circuit represents the temperature of the process fluid at the thermocouple. The closed control loop is now completely simulated.

The circuits used to simulate backlash and dead time are shown in Figs. 8 and 9. Although these circuits required much development time and work, they are now versatile and basic circuits that can be applied quickly to any similar process problem involving dead time and hysteresis.

The computer circuit shown in Fig. 7, (which is the simulated process control problem) was wired onto the prepatch bay (Fig. 10). Interconnections were made to the console recorder which was used to give a permanent record of the computer "runs" or results, on 6-channel paper (Fig. 11).

Analyzing the System

The computer programming switch was turned to "Operate," with the computer circuit connected as shown in the circuit wiring diagram. The temperature of the fluid oscillated, or "hunted." By adjusting the elements on the computer, it was found that the oscillations were caused by the simultaneous presence of valve backlash and transport dead time in the system. If either of these system elements was not present, the system did not hunt; if both were present the system hunted. This was demonstrated by observing the output temperature first with the backlash circuit replaced by a simple 1:1 inverter, and then by observing the temperature with the dead-time circuit out and backlash reinserted in the circuit. An important point is that it is often difficult or impossible to predict which if any of the characteristics of the components of a system can be ignored. For example, the process engineer found it difficult to accept that a 1-percent hysteresis in the valve was causing instability.

The control system was stabilized by lowering the con-

Fig. 10. Patching the various elements into the patch panel bay of the computer.

Fig. 11. Physical system is analyzed by operating the computer programming switch and recording the "temperature" of the process liquid (and other elements in the system) on this GEDA R-5 6-channel recorder.

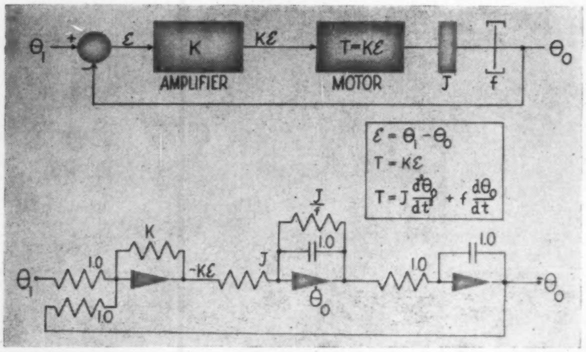


Fig. 12. Computer analysis of a position servomechanism. Top, closed-loop system; center, equations of motion; bottom, computer diagram.

troller gain (by means of a potentiometer). The oscillations became less severe and finally disappeared as the potentiometer gain was lowered.

With the system stable, the effects of disturbances on the output temperature next were investigated. A typical disturbance might be a change in the temperature of hot water going into the heat exchanger. A voltage to represent this disturbance was programmed into the computer by means of the utility switch. The response of the system to a step disturbance showed a prolonged response. The response was optimized by adjusting the controller parameters by means of the potentiometers.

In a few hours of computer operation the effect of each element in the system was established, optimum operation of existing equipment was realized, and design changes were indicated if further improvement was desired.

A Position Servomechanism Application

Many engineering systems are systems which can be described by a set of linear ordinary differential equations. Consider the simulation of a linear position servo system (shown at top in Fig. 12). The major components of this system are an input member, an output member, a differential device to indicate the error between the positions of the input and output members, an amplifier, and a motor which drives the output member by producing a torque that is proportional to the error. The motor has a viscous drag coefficient f and inertia J.

The equation of motion of the system is:

$$J\, d^2\theta_o/dt^2 + f d\theta_o/dt = K\, \epsilon$$

where K is the gain of the amplifier, ϵ is the error signal, θ represents angular position, and ϵ is the difference between the output angular position, θ_o, and the desired position θ_i:

$$\epsilon = \theta_i - \theta_o$$

The computer wiring diagram for this system is shown at bottom in Fig. 12. The system constants can be easily changed on the computer by changing the input and feedback resistors. As in the process control application, the effect of each element in the closed-loop control system can be evaluated and optimized.

Machine Variables and Scale Factors

As the electronic differential analyzer is a voltage analog, all of the dependant variables of the machine are voltages. In the simulation of a dynamic system there is a direct relationship between the machine voltages and the variables in the dynamic system being analyzed. This relationship is expressed by *scale factors*. The scale factors are dimensional coefficients that are more or less arbitrarily chosen by the computer operator. The choice of scale factors determines the voltage levels in the computer. Large analog voltages are desirable in order to obtain maximum accuracy. On the other hand, the voltages must not exceed the maximum voltage range of the computing equipment. When amplifiers are overloaded the operator is warned by a flashing light.

It is desirable to know the approximate range of all the variables and their derivatives in order to select appropriate scale factors. If the ranges of the system variables are not known, and if the scale factors are chosen incorrectly, there is a possibility of overloading. However, this can be easily corrected by a change of scale factor or a redistribution of the gain in the wiring diagram.

As an illustration of the application of scaling, let us look briefly at the position servo problem (Fig. 12). A rather high-response servo is simulated. The summing amplifier subtracts output position θ_o from input position θ_i and multiplies the difference (error voltage) by the servoamplifier and motor gain K. Voltages θ_o and θ_i should be expressed as one volt per corresponding degree of rotation so that normal sizes of input angle commands and output angle responses will correspond to reasonable voltages, say 10 to 80 volts. For sizeable inputs it is likely that transient errors of several degrees will be experienced by the servo. For a commercial servo it is likely that the servo-amplifier output ($K\epsilon$) would be reasonably linear for outputs of about 200 volts. To avoid overloading the computing amplifier the feedback resister could be lowered to K/2 so that the output of this amplifier would be $-K\epsilon/2$. The servo output velocity might be several hundred degrees per sec., which would correspond to several hundred volts in the computer circuit. Therefore, it would probably be best to compute, let us say, $+ (1/10)(d\theta_o/dt)$. This can be accomplished by changing the input resistor of the second amplifier to 5J thus lowering the amplifier gain by a factor of 5. The output position $(-\theta_o)$ is computed from $+ (1/10)(d\theta_o/dt)$ by changing the 1.0-megohm input to the third amplifier to a 0.1-megohm resistor. By this series of gain settings in the computer circuit we are assured that the computing amplifiers will not be working in either their low-voltage or saturation ranges.

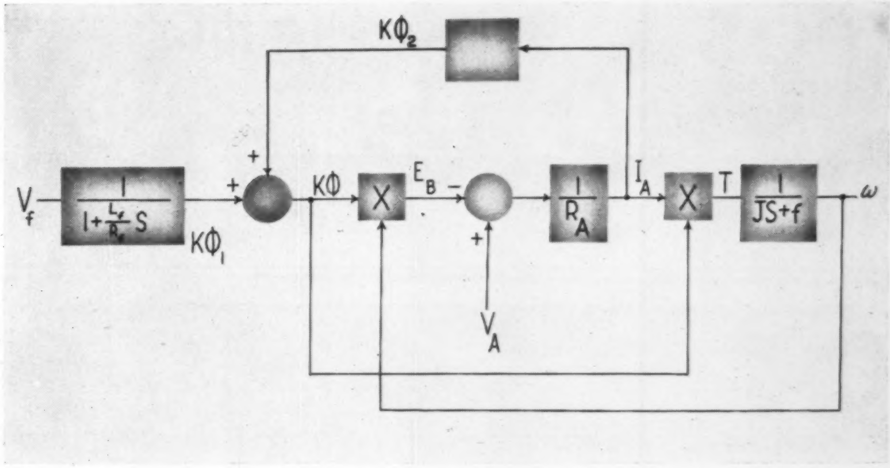


Fig. 13. Block diagram showing transfer-function descriptions of each element in a d-c motor.

Time Scale

The applicability of analog computors can be extended by the use of time-scale changes. If fast or slow systems are to be analyzed by analog-computer methods, it may be desirable to change the time scale. Fast systems are those systems which have high-frequency components compared to the frequency for which the analog-computing equipment was designed. Slow systems are those systems which require a relatively long time for solution.

Real time, also known as *machine time* τ, is the independent machine variable. The independent time variable t, is related to the machine time by a transformation equation

$$\tau = Kt$$

The solution time can be slowed down by choosing $K > 1$, and speeded up by choosing $K < 1$. The machine equations are formed by substituting this equation for τ into the original differential equations with t in them. The wiring diagram is then drawn from the machine equations. For the computer solution to be interpreted correctly, the machine time variable τ must be transformed back to the mathematical variable t. It is often desirable to change the time scale after the wiring diagram is drawn. If the solution time is too short it will be difficult to record and read; if too long it will waste time. The only change necessary is a change in gain of each integrator (1/RC).

Motor Analysis

Another application of interest is the study of relations in a simple d-c motor. The computer circuitry to represent this system involves the use of multipliers. The block diagram (Fig. 13) of the system is built up from the fundamental relations which describe the system:

V_f = The shunt field voltage
Φ_1 = The shunt field flux developed
E_b = The motor back-emf
V_a = Armature voltage
R_a = The armature resistance
Φ = The total flux active
Φ_2 = The series field flux
T_D = The torque developed by the motor
J = The combined moment of inertia of the motor and load
f = The viscous drag on the motor
ω = The motor shaft speed
T_L = The load torque applied
s = Operator d/dt (no initial conditions)

The fundamental relations that describe the motor operation are:

$$\Phi_1 = K_1 I_f$$
$$V_f = I_f R_f + L dI_f/dt$$
$$\Phi = \Phi_1 + \Phi_2$$
$$\Phi_2 = K_2 I_2$$
$$I_f = V_f/(1 + Ts)(R_f)$$
$$K_s \Phi \omega = E_b$$
$$V_a - E_b = I_a R_a$$
$$\begin{aligned} T_D &= K_t \Phi I_a \\ &= J d\omega/dt + f\omega \\ &= (Js + f)\omega \end{aligned}$$

The series stabilizing field will also be proportional to armature current, and the fields are connected for aiding fluxes.

Computer Diagram for D-c Motor

For purposes of this discussion, approximate constant parameters for a 1750-rpm, 5-hp motor are used. The computer circuit diagram (Fig. 14) for the d-c motor follows from the motor block diagram (Fig. 13). A voltage ($0.4\ V_f$) is applied to a time-constant circuit which represents the time constant of the field in order to compute the flux ($-20K_1\Phi_1$). The computer voltage representing the flux ($-20K\ \Phi$) is an input to a multiplier. The other input to the multiplier is $\omega/5$, which, we can assume for the moment, has already been calculated. The output of the multiplier is a voltage representing the motor back-emf ($-E_b/25$). This voltage is subtracted from an applied voltage representing the armature voltage, $V_a/25$. In this same summing amplifier a gain $25/R_a$ is incorporated.

The voltage output of this amplifier is armature current ($-I_a$). This voltage ($-I_a$) is an input to a multiplier. The other multiplier input is $-20\ K\ \Phi$, which was calculated previously. The output of the multiplier is a voltage representative of torque developed by the motor. This voltage ($0.27T_D$) is the input to a time-constant circuit which calculates the rotor speed resulting from the developed torque. By means of changes in the capacitor in the feedback circuit, the increase or decrease of inertial load on the system can be simulated. The voltage output ($-\omega/5$) of this amplifier is, then, representative of rotor speed. Rotor-speed voltage is the output of the system (as will be recalled this voltage was needed elsewhere in the circuit in order to calculate back-emf on the motor). As a voltage representative of armature current has been computed, the series field flux (Φ_2) can be computed by means of a simple coefficient multiplication, or gain. The coefficient is set on a potentiometer. The series field flux

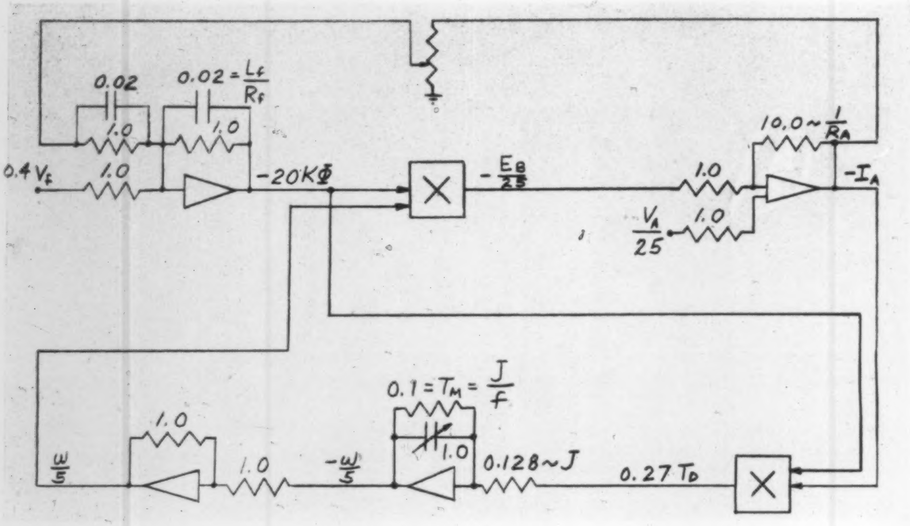


Fig. 14. Computer circuit diagram of the d-c motor of Fig. 13.

is summed with the shunt field flux in an amplifier, which also accounts for the shunt-field electrical time delay. However, the series field has no time delay to speak of; therefore, the effect of the time-constant circuit (0.02 mfd in parallel with 1 megohm in the feedback circuit) must be cancelled by a lead-circuit input to the flux summer. The lead time-constant is the same as the lag time-constant representing the shunt-field delay.

It is easy to observe the starting current and torque transients for the field and armature voltages chosen. By adjusting the field and armature voltage levels and the amount of series field (by means of the series-field gain potentiometer) it is possible to study their effects on the starting transients. This is a difficult study to make by pure analytic methods.

The effects of inertial load changes on rotor speed can be studied. Sudden changes in inertia can be simulated by switching parellel capacity in and out in the feedback circuit of the amplifier (representing the motor load time delay). Both the transient or "surge" effects and the steady-state effects on armature current, speed, etc., may be observed.

The important points brought out by this example are that in an analog computer (1) one may proceed from fundamental relationships to the complete analysis of a fairly complicated system, and (2) the analysis of nonlinear systems is no less straightforward.

Advantages of Differential Analyzer Use

Analog computers provide several important advantages in the study of engineering problems. In linear systems (where analytical solutions are possible) it finds application because of the simplicity and rapidity with which solutions are obtained. Particularly in dynamic systems in which the analytic solution involves point-by-point calculations, the availability of a computer encourages studies that would be too time consuming if carried out analytically. Where nonlinearities are involved, the only hope of obtaining any useful solution often lies in the use of a computer. A distinct advantage of the analog computer is that it is easily set up for problem solution. The average engineer can learn to operate one capably in a few week's time. As each section of a system can be separately simulated if desired, the effect on the system of changing the transfer function of any section can be determined readily. This ability furnishes the engineer with a better understanding of the system under study because the solutions are produced in a form already familiar to him.

Typical Applications

The electronic analog computer can be employed to study and/or design and develop any system for which the governing mathematical *or empirical* relations can be written. Typical applications already made include:

1. *Aircraft Engineering*:

Aircraft and missile automatic navigation and control problems, including autopilot design. Optimum control sensitivities are located in a fraction of the time possible by desk calculation.

Aircraft engine controls: A test stand has been built which, with hydraulic and computer equipment, simulates the in-flight jet engine. This stand is being used to develop better automatic fuel controls for jet aircraft.

Helicopter controls: Controls which will permit a pilot to leave his helicopter untended in hovering flight.

Landing shocks: Computers have been used to develop an anti-skid braking device.

Heat flow problems in structural members have been studied with computer aid. In the design of aircraft trainers, computers have been valuable.

The computer has been used to simulate aerodynamics and has been used with actual components of aircraft controls. The purpose of such setups is to find the effects of "bugs" in the components on the control problem.

2. *Mechanical and Automotive Engineering*:

To study vibrations in building and machine members.

To study the dynamics of linkages, cams, valves.

To study the design of suspension systems in automobiles.

To study the dynamics of hydraulic transmissions and power devices.

To study hydraulic and heat flow problems.

To help design pneumatic and electro-hydraulic controls for production machinery such as profilers, etc. Analog computers have been used as controllers for some production machinery.

3. *Chemical Engineering*:

In the study and design of chemical process controls.

In continuous process analysis such as nuclear products process control.

In nuclear chemistry studies of the relations in nuclear reactor control.

4. *Operations Research and Economics*:

Evaluation of the efficiency of a plant with breakdowns and maintenance considered.

To study the economic distribution of power to loads from multi-station systems; in the study of the plant-traffic flow problem.

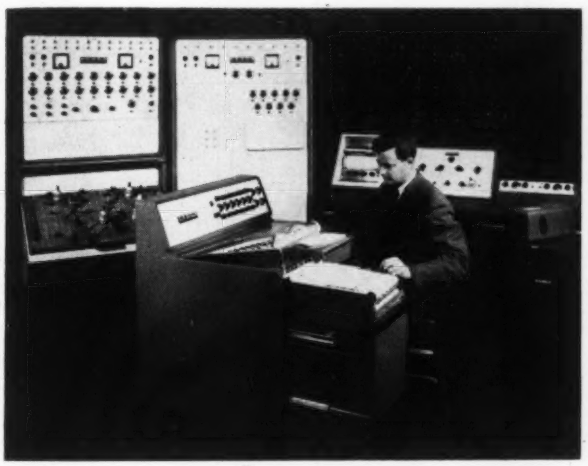


Fig. 15. A complete computer set-up, showing L-3 linear computer, N-3 nonlinear computer, C. D. Morrill sitting at an R-5 6-channel recorder, a revised Moseley Autograf recorder; an M-1 bridge for resistors and capacitors, and an R-3 2-channel recorder.

5. *Military Engineering and Ordnance*:

War games problems have been solved. In ballistics research, trajectory problems including spin and nonlinear drags, etc. have been solved.

6. *Marine Engineering*:

In the study of the stability problems of underwater and surface vessels and investigation of propeller cavitation.

7. *Electrical Engineering*:

Research and development work in servomechanisms, linear and nonlinear.

Evaluation of the effects of noise on control systems.

Network design; pulse formers, filters.

Analysis and development of rotating machinery and its control.

Analysis of transmission lines and modulation problems.

Design of components such as magnetrons, cathode-ray tubes, and transistors.

8. *Petroleum Engineering*:

Oil-field recovery; conservation of oil by proper programming of pumping to get the most out of the ground.

Pipeline analysis for oil transportation problems.

9. *Civil Engineering*:

Box-car coupling studies.

Water-hammer problems in dam sites.

Flood control and reservoir design. To predict flood crests in consideration of topology, rainfall, erosion, etc.

10. *Mathematics*:

Basic research in mathematics; solution of important definite integrals; research in nonlinear mechanics; conformal mapping.

Concluding Remarks

The use of feedback in industrial process controls is not a new idea. Furthermore, analog computers have been used for about ten years in the study of closed-loop systems. What is new, perhaps, is the application of this well-established tool to a well-established industry.

One argument frequently encountered when the application of analog computers to industrial control problems is suggested is that data of sufficient quantity and quality are seldom available. Two explanations of this situation are often given: (1) it is impossible, or at least uneconomical, to stop production long enough to obtain the necessary data, and (2) instrumentation, particularly of intermediate phases of a process, is difficult.

There is no pat answer to this problem.

The aircraft industry is often faced with the same problem. An example is the design of an autopilot for an airship. Equations describing airship motions are extremely nonlinear; effective mass, lift, and drag are functions of airspeed and angle of attack. Just as it is not feasible to stop production long enough for the process engineer to obtain the data he needs, the pilot of an airship cannot maintain a given stick deflection long enough for the engineers to obtain all the data they need. Furthermore, instrumentation of such variables as stick motion, roll angle, airspeed, etc., is no more refined in the aircraft industry than it is in the control industry. The aerodynamicist is forced to take data "on the run."

The procedure for attacking this problem might be: (1) make an educated guess as to the equations describing the motion of the airship; (2) obtain "in-flight" data on the arbitrary stick motions and resultant airship motions; (3) set up the airship equations on the analog computer; (4) reproduce the recorded stick motions as electrical signals and apply them to the computer; (5) observe the computed airship motions, compare them with the recorded motions, and modify the equations until satisfactory agreement between the two is reached.

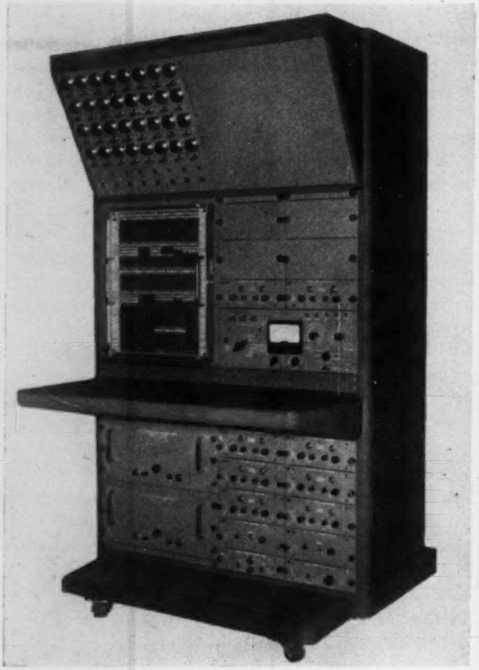
There are two fundamentally different approaches to analog computing. One of these is the mathematical approach wherein equations—usually differential equations—are solved in a straightforward manner. Where integration is indicated, an integrator is used; a change of scale calls for the use of a potentiometer, etc.

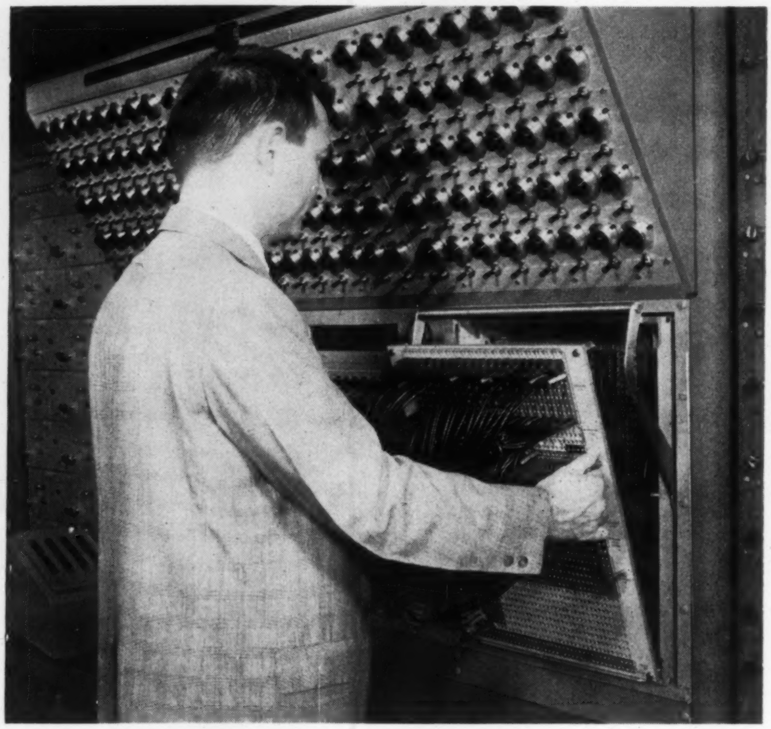
The second approach, the one employed in this article, emphasizes simulation. Where a time constant is indicated, an equivalent electrical network is used; dead space, backlash, dead time, limiting, are simulated by electrical or electronic circuits exhibiting analogous characteristics. *Only transfer-function-type (empirical) equations for the equipment or process are required.*

The principal advantage of the mathematical approach is that the transition from solving equations analytically or by means of a desk calculator to solving them on an analog computer is less abrupt. In addition, patching is usually simpler and requires less time.

There are several advantages to the simulation approach to analog computing. The first advantage is that greater flexibility is afforded. This increased flexibility almost always results in a greater economy of computing units: the number of operational amplifiers required to solve a particular problem may be reduced by 2:1 or more. This greater flexibility also permits the inclusion of the type of nonlinearities or discontinuities frequently encountered when attempting to improve the reliability or reduce the cost of a control system by using off-on actuators, saturable amplifiers, inexpensive gearing, or time-shared components. Perhaps the most important advantage of the simulation approach to analog computing is that the engineer obtains a much better grasp of the system he is studying and is, therefore, better able to improve its reliability and performance.

One question which frequently disturbs many potential users of analog computers is: "How can I be sure that the analog computer will actually do for me what is claimed"? Fortunately, this is no longer a serious problem. Most manufacturers of analog computers maintain some facility for solving problems for a nominal fee. In addition, there are many computing centers located throughout the country which will handle on a contract basis problems requiring computers. Today there is no reason why every company with extensive use of control equipment should not investigate fully the advantages it may derive through the use of analog computers.





↑Fig. 1. Model 16-31R analog computer.
Fig. 2. Inserting patch panel into computer. ⟶

A Practical Approach to ANALOG COMPUTERS

TODAY'S ANALOG COMPUTER has behind it a substantial record of achievement. Initially assembled to solve problems of guided-missile trajectories and airframe design, its use has spread rapidly into other fields. Process control studies and analysis of automatic control systems are probably the most important and promising of these new fields.

Use of the analog computers is presently limited by lack of familiarity with them by many engineers. The numerous knobs, dials, and indicators tend to confuse the neophite and give the impression of complexity. However, an analog computer is simple to operate, and the average engineer who has some electrical experience can be taught to operate it in as little as eight hours. With a week of practice and study he can successfully set up and run routine problems.

This article has been written for such an engineer—one who has heard glowing descriptions of what analog computers can do and who wants to know how the computer would solve such problems. Although more than twenty-five types of analog computers are available in today's market, the basic principles by which they operate are virtually identical so that a detail description of one type will provide an adequate introduction to the field. The following is based on the Electronic Associates' Model 16-31R (Fig. 1), a typical general-purpose computer.

Presented at the Computer Clinic, First Automation Exposition, New York, N. Y., Nov 30-Dec. 2, 1954.

Electrical Analogs

In an analog computer, physical variables such as weight, temperature, or area are represented by voltages—that is, voltage is the electrical analog of the variable being analyzed. Arbitrary scale factors relate voltages in the computer to the variables or parameters in the problem being solved. These scale factors may be of the form 5 volts equals 1 inch; 100 volts equals 0.4 square feet; -100 volts equals 2 ounces, etc. Either positive or negative voltages can be used to represent physical quantities in the problem.

Reference Supplies

All signal voltages within the computer are obtained directly or indirectly from a master voltage source known as the reference supply. This supply has two output voltages, -100 and +100 volts. The computing units are designed so that they will operate reliably on these voltages. In problems where the answer is appreciably larger or smaller than the input quantities, different scale factors are used for inputs and outputs or within the problem. This is not difficult. In some cases, the components are more accurate if used at higher voltages. This dictates using large scale factors to retain accuracy, but not large enough to exceed the 100-volt limitation. Practical problem set up requires a compromise between these two effects.

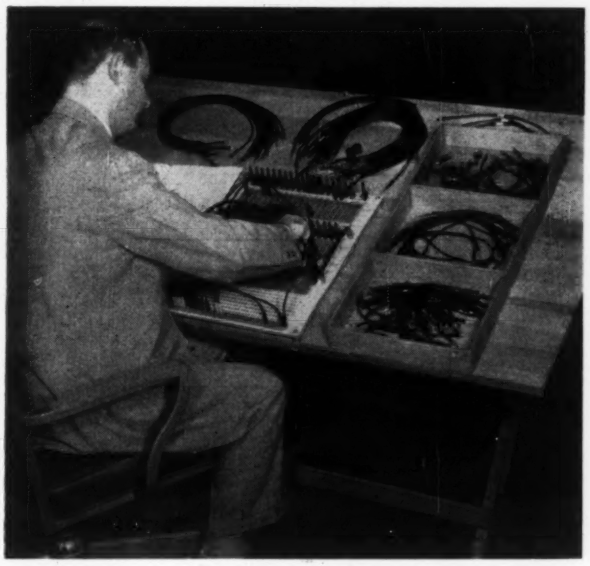


Fig. 3. Panel being patched externally to the computer. Note various lengths of patch cords and solid "bottle plugs" used to connect any two adjacent holes on the patch panel.

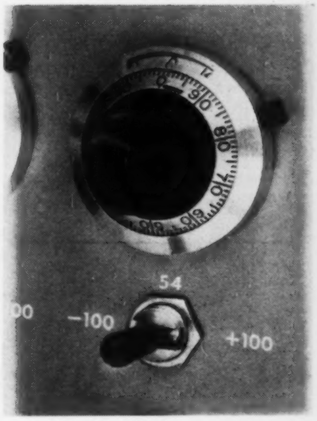


Fig. 4. Attenuator 54 and ± reference switch.

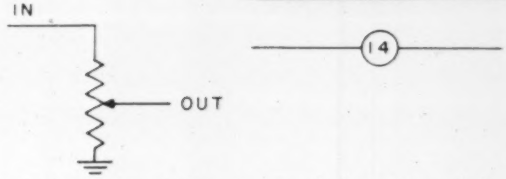


Fig. 5. Attenuators. Left, conventional electronic symbol; right, computer symbol for attenuator number 14.

JOHN D. STRONG

Electronic Associates, Inc.

In the preceding article, the basic operations and techniques for use of a general-purpose analog computer were discussed, with emphasis on applicable techniques. Now we look more closely at each unit—attenuators, amplifiers, etc.—and go to work setting up specific problems.

Input Equations and Data

Two types of input information are required for the computer. The first type is the mathematical equations describing the problem. These equations are set up on the patch board which is inserted into the computer (Fig. 2).

The problem boards may be set up, or "patched," external to the equipment (Fig. 3) or while the patch board is in place in the computer. Safety features are incorporated in the equipment to prevent computer damage from patching errors. Patching is performed with shielded patch cords of various lengths, as shown in Fig. 3. The shield is connected to a metal sleeve at each end of the patch cord and is grounded when the patch cord is inserted into the aluminum patch panel. The signal pin at each end of the patch cord contacts a spring behind the patch panel. Two-prong red and green *bottle plugs* are used to connect two adjacent holes on the patch panel. Four-prong orange bottle plugs are equivalent to two green bottle plugs side-by-side.

The second type of input information consists of numerical values for the constants and parameters in the problem. This data is inserted by means of attenuators (potentiometers) which are located above the control panel (top of Fig. 1). Each attenuator has a dial which enables it to be set to within ± 0.5 percent of the proper value. As many problems require greater precision, more accurate means are usually used to set attenuators to an accuracy of ± 0.01 percent.

Attenuators

Attenuators are represented by the symbol shown in Fig. 5, where the number in the circle indicates which attenuator is to be used. This symbol is equivalent to the conventional radio symbol for an attenuator, as shown in Fig. 5. Normally, two leads are brought from each attenuator to the prepatch panel, the arm (output) and the top (input). The bottom end is grounded at the potentiometer and does not appear on the patch panel.

A switch below each attenuator (Fig. 4) enables it to be connected to the plus or minus reference supply; this reduces the number of patch cords used and the time required to patch problems. Fig. 6 shows the patch-panel terminations for a typical attenuator. Occasionally it is desirable to apply a voltage to the bottom of an attenuator as well as to the top. Therefore, a few attenuators are connected as shown at the right in Fig. 6.

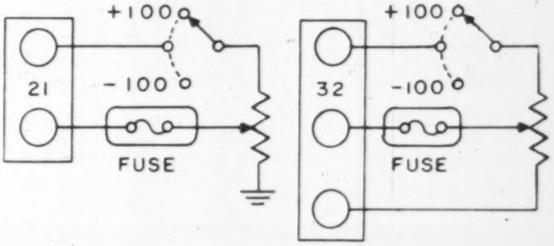


Fig. 6. Attenuator terminations, grounded (left) and ungrounded (right).

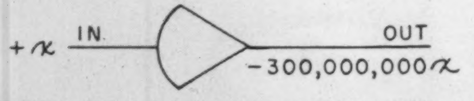


Fig. 7. Triangular symbol for the operational amplifier, a high-gain d-c amplifier with a gain of 300 million. The operational amplifier is a basic computer element because, with simple feedback circuitry, it becomes an inverter, summer, integrator, etc.

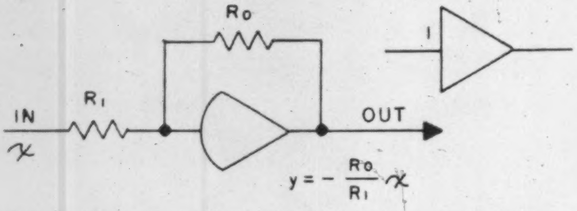


Fig. 8. When R_0 equals R_1 (1 megohm in practice), the operational amplifier is an inverter—that is, it multiplies the input by minus unity. Symbol for inverter is shown at upper right. Note that for other values of R_0 the circuit is a coefficient multiplier. When several inputs are used, as in Fig. 9, the circuit is a summing amplifier.

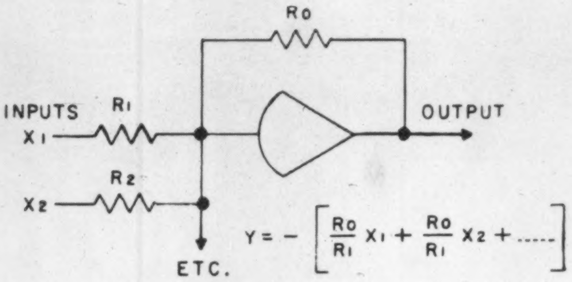


Fig. 9. Schematic for summer.

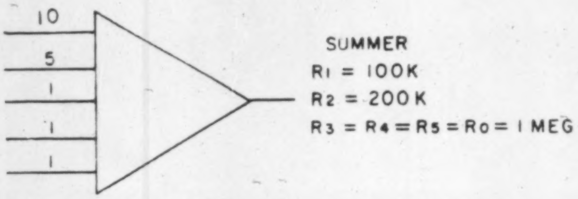


Fig. 10. Standard summing amplifier with 5 inputs.

Operational Amplifiers

Several mathematical operations, including addition and subtraction, are performed by a component known as an operational amplifier (Fig. 7). These d-c amplifiers have a high gain; an input voltage of plus 1/300 millionth of a volt produces an output voltage of minus 1 volt. In other words, the gain of the amplifier is 300 million.

Inverter

Fig. 8 shows use of an operational amplifier as an inverter (multiplication by –1). If $R_0 = R_1$, the output voltage will substantially equal the negative of the input voltage. For an amplifier gain of 300,000,000 the error in the output is less than one part in 100,000,000. The standard value of R_0 and R_1 for inverting amplifiers is 1 megohm. The symbol for an inverter also is shown in Fig. 8.

Frequency Response

The frequency response of an inverter is flat (± 6 percent in amplitude) from zero to 20 kc. In order to keep errors below 0.01 percent, the inverter is used only from zero to 100 cycles per second, where its frequency response is flat within ± 0.01 percent in amplitude. This is usually not a limitation because the devices which plot the output of an analog computer cannot respond accurately to frequencies above 50 cycles per second.

Summer

It is possible to connect additional input resistors to an inverter as shown in Fig. 9. If all of the input resistors and the feedback resistor are equal, the output will be the negative sum of the input voltages. By changing the ratio of an input resistor to the feedback resistor, it is possible to multiply an input by that ratio before it is added. In the standard summing amplifier with 5 inputs (Fig. 10), first input resistor is 0.1 meg (multiplying the first input by 10 before it is summed); the next input resistor is 0.2 meg (multiplying by 5 before the addition); the remaining inputs use 1 meg resistors. The output of the summing amplifier is:

$-1\ (10\ \text{Input}_1 + 5\ \text{Input}_2 + \text{Input}_3 + \text{Input}_4 + \text{Input}_5)$.

The operational amplifiers are located on chassis mounted in the control console or adjacent racks. Two amplifiers are mounted on each amplifier chassis (Fig. 11). Balancing adjustments and overload indicators are located on the front panel of the chassis. The input resistor and feedback resistor are located in a thermostatically controlled oven.

Ten dual-amplifier chassis are provided on the basic 16-31R computer (Fig. 1); 14 dual chassis can be supplied on a vertical grouping called the 16-31C Amplifier Group if more amplifiers are required.

Summer Terminations

Amplifiers 21 to 48 are connected as summing amplifiers, and their terminations appear on the patch panel as shown in Fig. 12. The four holes in the top of the pattern should be filled with a four-prong bottle plug. This connects the feedback resistor and the input resistors to the summing point. Connections for the rest of the holes are shown at the right (assuming that the bottle plug is in place). Several output connections are made available so that the summer may be connected to various places within a problem simultaneously. Only those inputs which are used need be connected. (Amplifiers 1 to 20 are connected as combination—integrating or summing—amplifiers, as will be described later.)

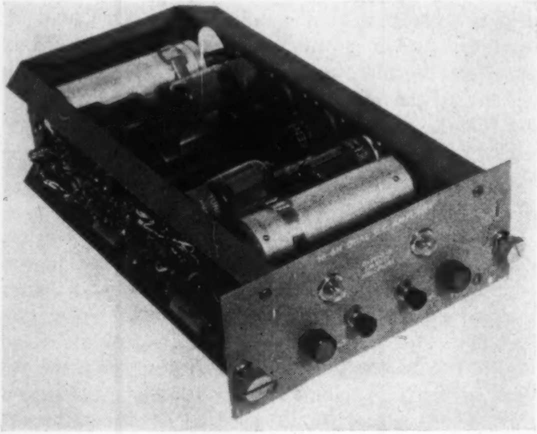


Fig. 11. Dual-amplifier chassis.

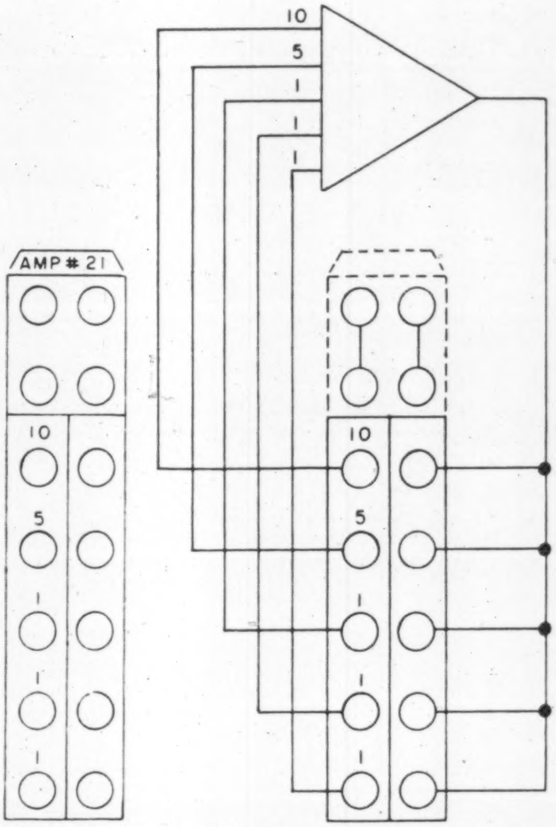


Fig. 12. Summing amplifier pattern on patch panel (left) and terminations (right) showing how patch panel is connected internally to summing amplifier.

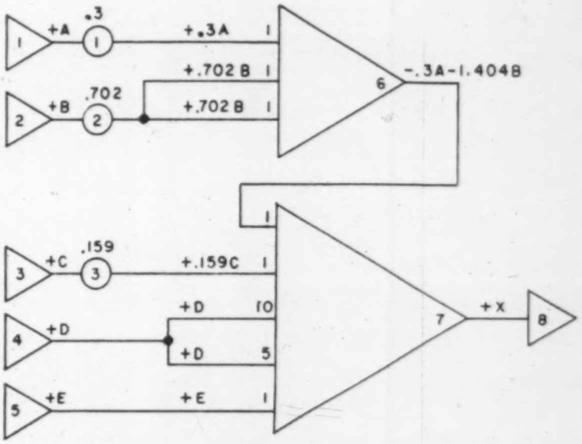


Fig. 13. Machine schematic for sample addition-subtraction problem: $x = 0.3A + 1.404B - 0.159C - 15D - E$. Amplifiers 1 through 5 provide inputs A, B, C, D, and E. Attenuators 1, 2, and 3 attenuate A, B, and C as required. Summing amplifier 6 sums up the two positive inputs and delivers them as a negative sum to summing amplifier 7. Amplifier 7 sums all five terms and delivers a positive output, which is the desired sum, + x.

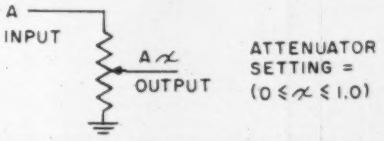


Fig. 14. Attenuator multiplies by a fixed factor which must be less than unity.

Typical Addition-Subtraction Problem

We have glanced at the elements in the general-purpose analog computer and their appearance on the computer. Let us now consider a sample addition:

$$x = 0.3A + 1.404B - 0.159C - 15D - E$$

The machine schematic for making this addition is shown in Fig. 13. As two factors are added and three subtracted, two amplifiers must be used—one for inverting the positive factors. Amplifier number 6 in Fig. 13 is used to add and invert the A and B terms. Amplifier number 7 performs the final addition.

Input A is connected to the top of an attenuator set to 0.3, and the arm is connected to a 1 input of summer 6. Input B must be multiplied by 1.404 before inversion. The method shown in Fig. 13 requires setting an attenuator to one-half the desired value and connecting the arm to two 1-inputs simultaneously.

Another method which could have been used would involve setting the potentiometer to one-fifth of the desired value and connecting the arm to a 5 input. The output of amplifier 6 ($-0.3A-1.404B$) is connected to a 1 input in Amplifier number 7. Input C is connected to an attenuator set to 0.159 and the arm is connected to a 1 input. Input D is connected to a 10 and 5 input simultaneously to give the required multiplication factor of 15. Input E is connected directly to a 1 input. The output of Amplifier number 7 is then + x.

Loading Effect

In Fig. 13 the numbers above the attenuator symbols refer to the "setting" of the attenuator. The setting is defined as the ratio of the voltage at the arm to the voltage at the top of the attenuator. If nothing is connected to the arm, this setting will equal the attenuator dial reading. In practice the arm is usually connected to a load such as a 1-megohm or 100K amplifier-input resistor. The current drawn by such a load reduces the voltage at the arm below the value indicated by the dial setting by as much as 5 or 10 percent. This is known as a loading effect. To correct this effect it is necessary to set the attenuator dial somewhat higher than the "setting" by an amount known as the *loading correction*. It is theoretically possible to set the attenuator dial higher by an amount indicated by a loading correction graph. In practice this is undesirable because it does not take into account linearity errors in the attenuator. A more convenient and accurate method involves applying 100 volts to the top of the attenuator while the load is connected to the arm. The dial is then adjusted until the voltage at the arm is correct. The voltmeter used must be accurate and must have a high input resistance so that it will not cause loading errors.

The problem in Fig. 13 presumes that the input voltages A, B, C, D, and E are available only in their positive form. Frequently, in problem hook ups, various voltages are available only in their minus form, or sometimes in both minus and plus forms. If voltages A and B had been available in their minus forms, it would not have been necessary to use Amplifier 6 in Fig. 13.

Multiplication

Multiplication *by a fixed quantity* can be performed as indicated in Fig. 13 by using attenuators and summing amplifier inputs of 5 or 10. The attenuator alone (Fig. 14) multiplies by a fixed factor of less than unity.

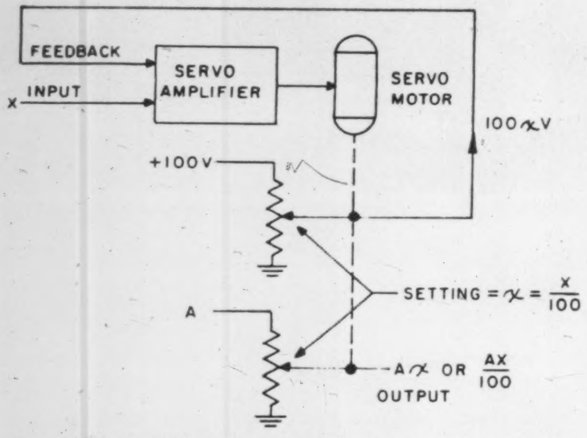

FEEDBACK
SERVO AMPLIFIER
INPUT
x
SERVO MOTOR
100𝓍V
+100V
SETTING = 𝓍 = x/100
A
A𝓍 OR AX/100
OUTPUT

Fig. 15. Servomultiplier uses servo motor to position attenuators. Input x (positive only) causes servo motor to position both attenuators. Therefore, output of bottom potentiometer is Ax. Top potentiometer (or cup) is simply a follow-up cup. A can be positive or negative.

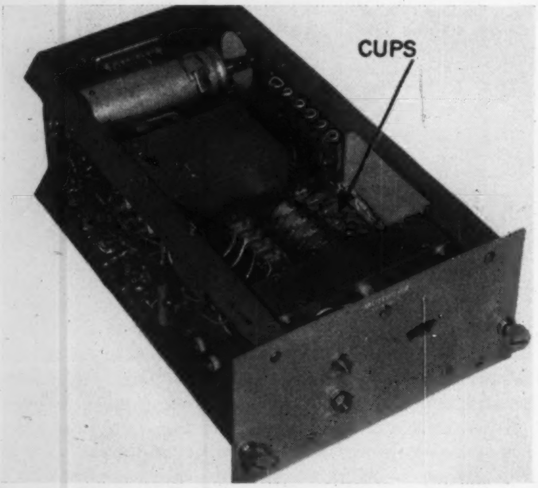


Fig. 16. Servomultiplier chassis contains servo amplifier, servo motor, and six cups.

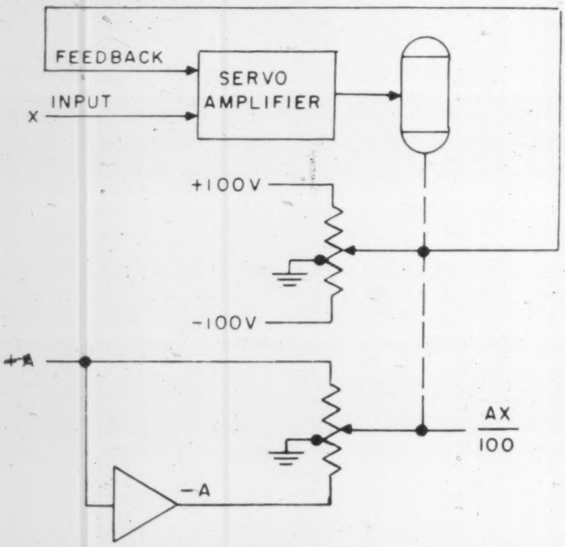

FEEDBACK
SERVO AMPLIFIER
INPUT
x
+100V
-100V
+A
AX/100
-A

Fig. 17. Servomultiplier for multiplying two voltages (A and x) when either can be positive or negative. Top cup (potentiometer) is follow-up cup positioned by x input; output is taken from bottom cup. Note how addition of one inverter accommodates negative x inputs (compare with Fig. 15).

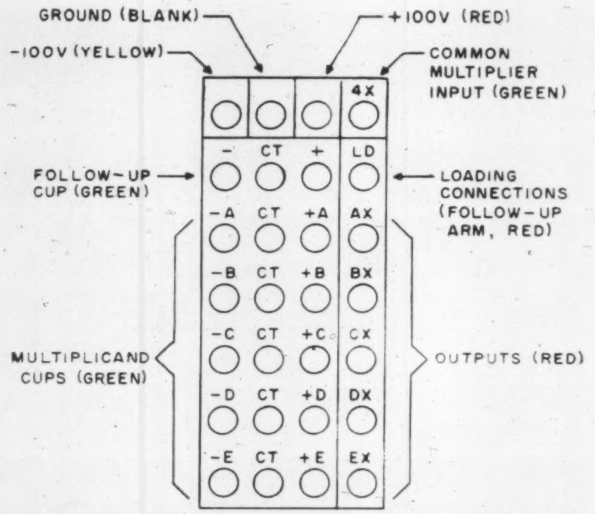

GROUND (BLANK)
+100V (RED)
-100V (YELLOW)
COMMON MULTIPLIER INPUT (GREEN)
4X
- CT + LD
FOLLOW-UP CUP (GREEN)
LOADING CONNECTIONS (FOLLOW-UP ARM, RED)
-A CT +A AX
-B CT +B BX
-C CT +C CX
-D CT +D DX
-E CT +E EX
MULTIPLICAND CUPS (GREEN)
OUTPUTS (RED)

Fig. 18. Servomultiplier terminations on patch panel, showing five output cups and one follow-up cup.

Multiplication *by a varying quantity* may be performed by an attenuator which is automatically positioned by an electric motor. This type of multiplier is known as a servomultiplier (Figs. 15 and 16).

The servo amplifier (Fig. 15) measures the difference in voltage between the two d-c inputs, and converts it to a 60-cycle voltage which drives the servo motor. This motor is geared to two or more attenuator arms. The attenuators are single-turn, 5-inch precision potentiometers, (Helipots), usually referred to as "cups" because of their shape.

In Fig. 15, voltage A may be either positive or negative and the output will change sign accordingly. The input voltage x can only be positive because a negative x would make the servo turn until it hits the limit stop at the bottom of the cups. The output will then be zero and hence incorrect.

To multiply two voltages when both may become either positive or negative, the circuit of Fig. 17 is used. If x is positive the servo will move to a point on the upper half of the cups corresponding to a setting of x/100; the output voltage on the arm of the second cup will be Ax/100. When x is negative the servo will move to a setting of x/100 on the lower half of the cup; this half of the cup is supplied from an inverter whose output is –A, and the output voltage will be negative as required.

Servomultiplier Terminations

A standard servomultiplier (Fig. 16) has 6 cups (1 follow-up cup and 5 output cups) and appears on the patch panel as shown in Fig. 18. Connections from the multiplier to the patch panel are shown in Fig. 19.

For convenience in applying voltage to the follow-up cup, reference voltages are located directly above the follow-up in the pattern. When the multiplier is positive, only the CT holes in the pattern are not used. Fuses are mounted in the multiplier chassis so as to protect all cups in event of patching errors.

Squaring and Cubing

By using more than one output cup on a servomultiplier, squares and higher powers may be generated. The circuit for generating x^2 and x^3 for positive or negative x is shown in Fig. 20.

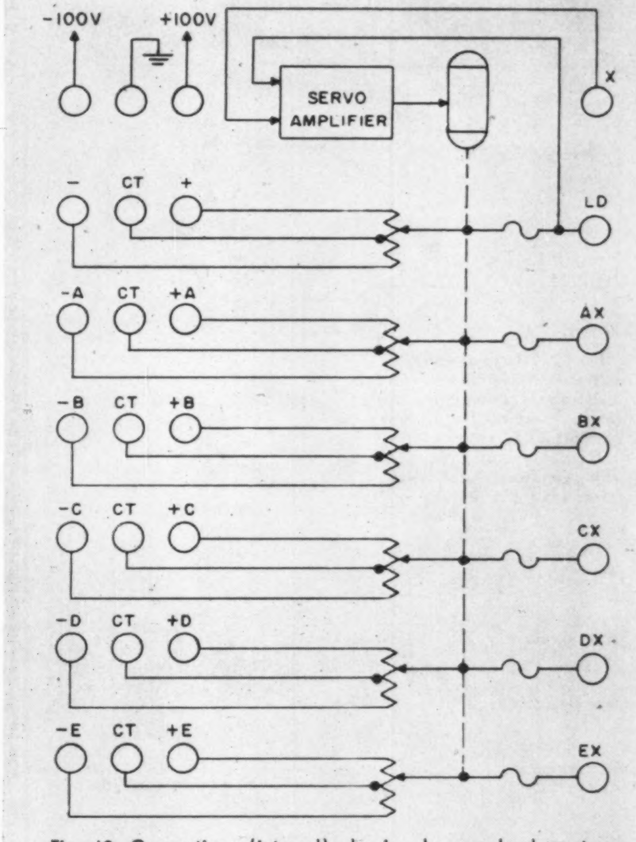

-100V
+100V
SERVO AMPLIFIER
X
-
CT
+
LD
-A
CT
+A
AX
-B
CT
+B
BX
-C
CT
+C
CX
-D
CT
+D
DX
-E
CT
+E
EX

Fig. 19. Connections (internal) showing how each element on servomultiplier chassis (6 cups and servo amplifier) are connected to patch panel.

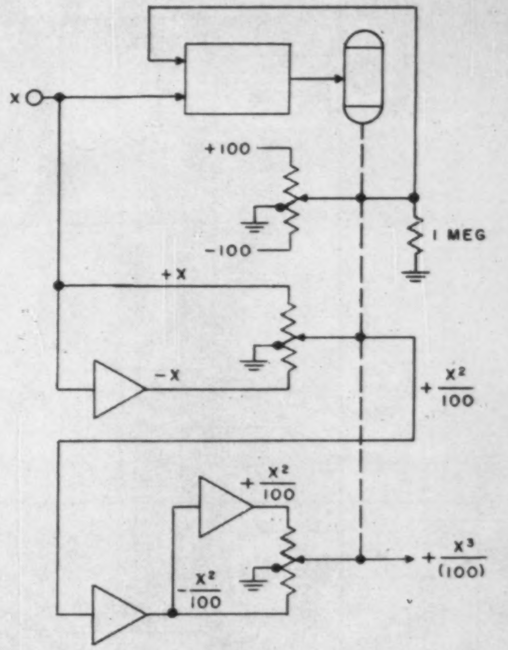

X
+100
-100
1 MEG
+X
-X
$+\frac{X^2}{100}$
$+\frac{X^2}{100}$
$-\frac{X^2}{100}$
$+\frac{X^3}{(100)}$

Fig. 20. Circuit for generating x^2 and x^3 when x is positive or negative. Note that this is a servomultiplier with x input connected to both amplifier and multiplying cup.

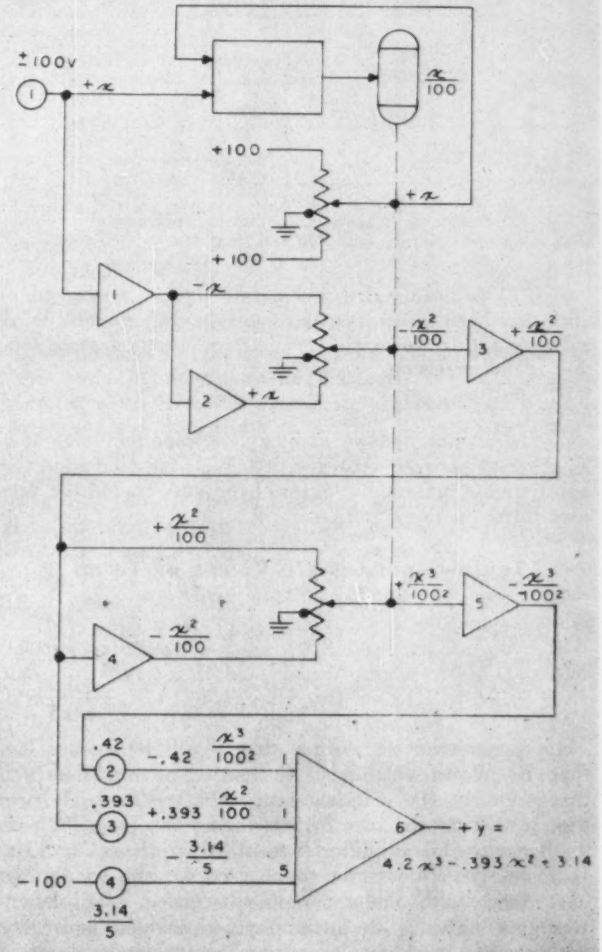

±100V
1
+x
$\frac{x}{100}$
+100
+x
+100
1
-x
$-\frac{x^2}{100}$
3
$+\frac{x^2}{100}$
2
+x
$+\frac{x^2}{100}$
$+\frac{x^3}{100^2}$
5
$-\frac{x^3}{100^2}$
4
$-\frac{x^2}{100}$
.42
2
-.42
$\frac{x^3}{100^2}$
1
.393
3
+.393
$\frac{x^2}{100}$
1
6
+y =
$4.2x^3 - .393x^2 + 3.14$
$-\frac{3.14}{5}$
5
-100
4
$\frac{3.14}{5}$

Fig. 21. Computer schematic for solving polynomial equation shown at lower right. (Correction: $4.2x^3$ should be $0.42x^3$ at lower right.)

Multiplier Loading

As with attenuators, a loading error occurs in multiplier cups due to amplifier inputs or other loads connected to them. (No loading error occurs in the follow-up cup because the servo amplifier draws no current from its inputs after the servo reaches its proper position). To overcome this difficulty, a loading resistor is connected to the follow-up cup arm (marked LD in the pattern in Fig. 18) so that it will be loaded the same as the output cups.

Sample Polynomial Evaluation

The squaring and cubing circuits can be used to evaluate polynomials of the following type where x is known and y the unknown:

$$y = 0.42\,x^3 - 0.393\,x^2 + 3.14$$

A computer schematic for one method of solving this equation is shown in Fig. 21. The value of x is set on attenuator 1 and the output read with a voltmeter at amplifier 6. Strickly speaking, amplifier 2 is not required since –x might be obtained directly from the arm of attenuator 1, although its loading would be high due to the bottom half of the x^2 multiplier cup. If we are to use the dial on attenuator 1 for even a rough indication of x, it will be considerably more convenient to have it loaded by an amplier input of 1 megohm rather than a "one-half cup" of 15,000 ohms.

The squaring and cubing circuits in Fig. 21 differ slightly from those previously given in order that the x^2 and x^3 terms will be generated with the proper signs to be used directly as inputs to amplifier 6.

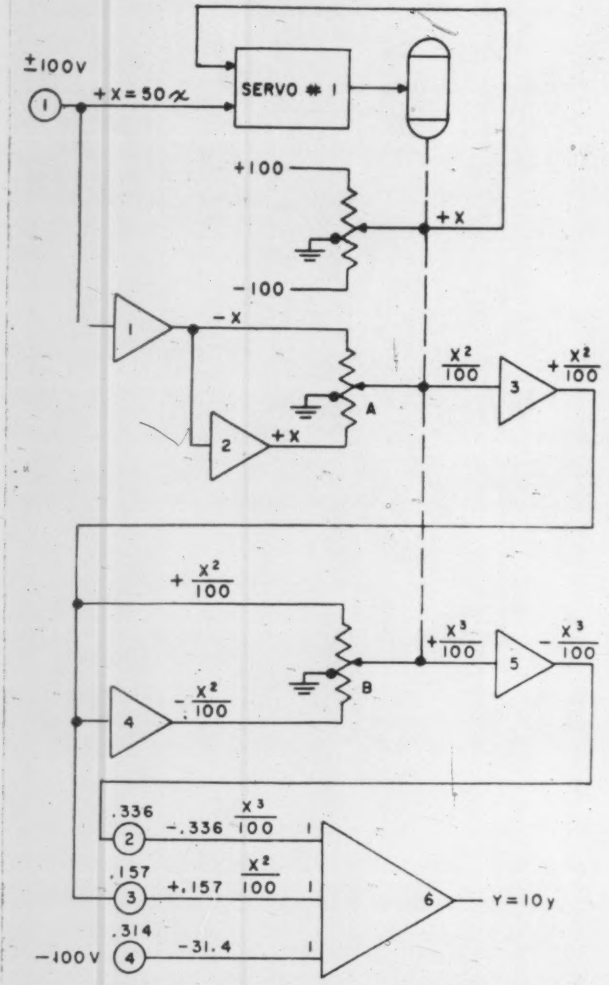


Fig. 22. Computer schematic for solving polynomial equation after using scale factors $Y = 10y$ and $X = 50x$.

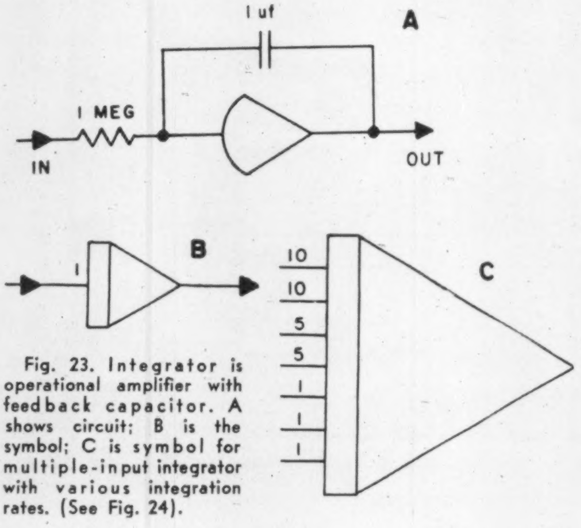


Fig. 23. Integrator is operational amplifier with feedback capacitor. A shows circuit; B is the symbol; C is symbol for multiple-input integrator with various integration rates. (See Fig. 24).

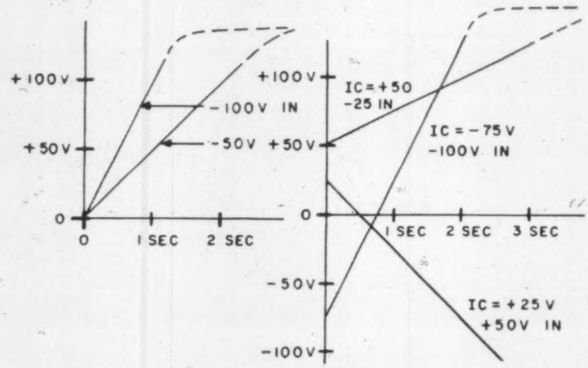


Fig. 24. Integrator output for various inputs (left), and (right) outputs with various initial conditions (as set up at IC on patch panel—see Fig. 25).

Fig. 21 is an unscaled schematic—that is, no consideration has been given to scale factors or the magnitude of voltages within the problem. Determination of scale factors is the next step.

Scale Factor

Let us assume that we wish to determine the value of y as x varies between –0.1 and 2.0. We first determine the approximate maximum values of the answer and the various terms in the equation:

Table—Approximate Values of Terms

Term	*at $x = -0.1$*	*at $x = 2.0$*
$+0.42\ x^3$	-0.0004	$+4.0$
$-0.393\ x^3$	-0.004	-1.5
$+3.14$	$+3.0$	$+3.0$
y	$+3.0$	$+5.5$

It appears safe to assume that y will be always less than 10. We then can scale the output of amplifier 6 so that it will be 100 volts when $y = 10$ and be fairly sure that it will not be overloaded during the problem run. If the output of amplifier 6 is called Y, then $Y = 10y$ indicates the scale factor to be used for the answer. In accordance with analog-computer practice, small letters represent the variables in the physical problem and carry their normal problem dimensions; capital letters describe the corresponding variables in the computer and carry the dimensions of volts with maximum values of +100 and –100 volts. (Some operators prefer the system in which computer variables are expressed as fractions of 100 volts. Their maximum values are then +1 and –1. Either system may be used although the "volt" system appears more convenient in practice.)

Optimum scaling requires that the maximum value of the setting on attenuator 1 be 1.0, corresponding to $X = 100$. If $X = 100$ volts when $x = 2.0$, then $X = 50x$. Substituting $Y = 10y$ and $X = 50x$ in the original equation yields:

$$Y = 0.0000336\ X^3 - 0.00157\ X^2 + 31.4$$

This may be re-written:

$$Y = 0.336\ X^3/100^2 - 0.157\ X^2/100 + 31.4$$

The scaled schematic based on this equation is shown in Fig. 22.

Plotting Curves

Although the polynomial may be evaluated point by point, it is usually more desirable to graph the answer on an X-Y plotting table whose pen is moved independently in the X and Y directions by two servos similar to those in the servomultiplier. Theoretically, it would be possible to plot the polynomial by connecting the arm of attenuator 1 to the X input of the plotter and the output of amplifier 6 to the Y input of the plotter. By turning attenuator 1 slowly by hand, the function would be plotted automatically. In practice, this method is too tedious. A device is needed which would generate an output voltage which in-

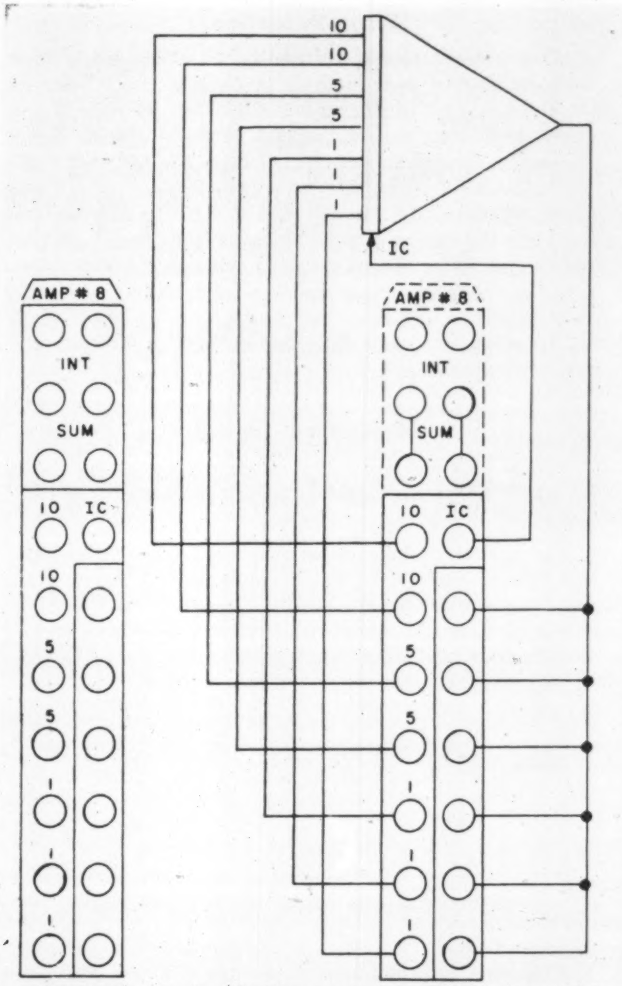


Fig. 25. Combination amplifier appears on patch panel as at left. With bottle plug inserted in 2nd and 3rd row (covering the word SUM and exposing the word INT), amplifier is connected as integrator as shown at right.

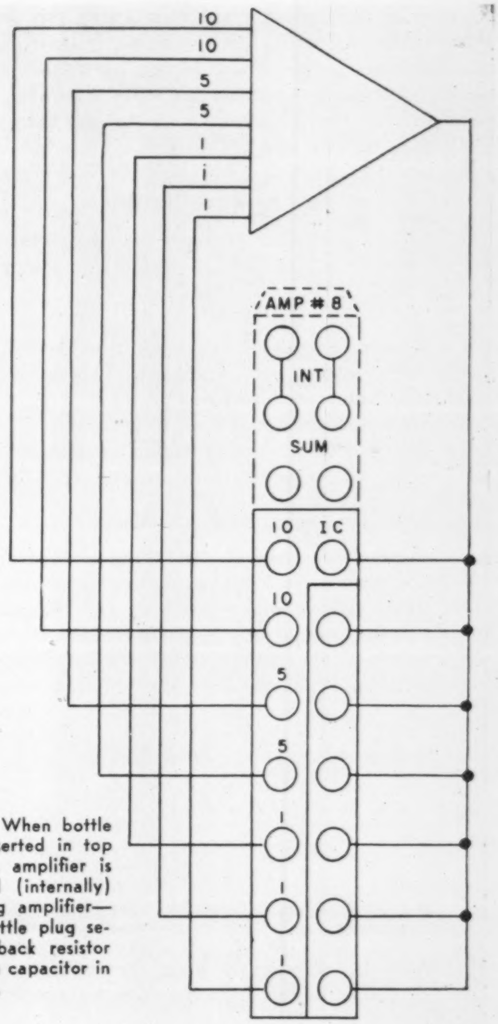


Fig. 26. When bottle plug is inserted in top four holes, amplifier is connected (internally) as summing amplifier—that is, bottle plug selects feedback resistor rather than capacitor in Fig. 23, A.

creases linearly with time and could replace attenuator 1. The device used in analog computers to perform this function is an *integrating amplifier.*

Integrating Amplifier

The integrating amplifier, or integrator, is identical to a summing amplifier except that the 1-meg feedback resistor is replaced by a 1-microfarad feedback capacitor (Fig. 23). For a constant input voltage, the output will be a linearly changing voltage as shown in Fig. 24. For a –1 volt input, the output will increase at a rate of +1 volt per second until the input is removed or the amplifier reaches its maximum output voltage. If x is the input and y the output, $x = -dy/dt$, or $y = -\int x\,dt$.

Multiple inputs may be used with an integrator, as with a summer. The symbol for a seven-input integrator is shown in Fig. 23, C.

Initial Condition

In many problems it is desirable to start an integrator at some voltage other than zero at the beginning of a problem (Fig. 24). This voltage is known as the initial condition of the integrator, and represents the value of the integrated variable at $t = 0$. An input marked IC is provided in the integrator pattern on the patch panel for insertion of the initial condition voltage. The integrators are set to their initial-condition voltages when the main control switch is turned to RESET.

Combination Amplifier

Amplifiers 1 to 20 are connected as combination amplifiers—that is, they may be used either as integrating amplifiers or summing amplifiers. Their pattern on the patch panel is shown in Fig. 25 (left). To use the amplifier as a summer, a 4-prong bottle plug should be inserted in the top four holes, leaving the word SUM exposed (Fig. 26). To use the amplifier as an integrator, the bottle plug is moved down one row, leaving the word INT exposed (Fig. 25).

Main Control Panel

The switch used to start and stop problems is located on the main control panel (to the left of the panel indicator in Fig. 1). It has 6 positions: STAND BY, REF OFF, POT SET, RESET, HOLD, and OPERATE.

In STAND BY, the plate supplies are off: in REF OFF, the plate supplies are on but the reference supplies are off; the switch should be in this position when patch cords are being removed or inserted in the patch panel. In POT SET, the reference voltages are turned on, and all amplifier input resistors are disconnected from their amplifiers and connected to ground. This permits attenuators to be set with the proper loading. Integrators are set to their initial conditions in RESET, and the problem is started by turning to OPERATE. If the operator desires to stop a problem before completion, he may do so by turning the main control switch to HOLD. In this position he can measure voltages within the problem in order to locate errors or determine magnitudes of the various terms in the equations. To continue the problem again, he turns the switch back to OPERATE. The summers will function as summers in the last three positions —RESET, HOLD, and OPERATE.

Falling-Body Problem

An extremely simple problem which demonstrates the use of integrators is the falling-body problem. A body falling freely obeys the equation

$$d^2x/dt^2 = -g$$

where x is the height of the body (plus x is up), and g is the acceleration due to gravity. This may be solved on the computer as shown in Fig. 27.

With attenuators 2 and 3 set to zero, the computer will solve the case of an object which is dropped "down a well"—that is, the initial position and velocity are zero.

Time Scale for Falling-body Problems

If we were interested in the falling body over a 10- or 15-second period, we would probably choose to solve it in "real time," where one second on the computer corresponds to one second in physical problem. If the solution had concerned the trajectory of a bomb dropped from high altitude, we might find the solution time of 3 or 4 minutes inconveniently long. In such event we can speed up the computer solution by making a time-variable substitution.

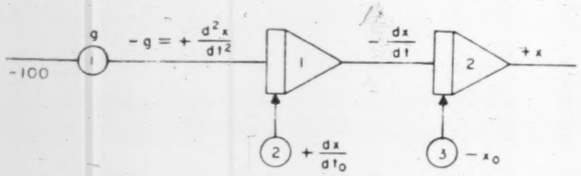


Fig. 27. Computer solution for falling-body problem.

If t = time in the physical problem, and T = time in the computer, we can speed up the problem by a factor of 5 if we let

$$5T = t$$

so that

$$d^2x/dt^2 = (1/25)\ d^2x/dT^2$$

The original equation may now be written:

$$d^2x/dT^2 = -25g$$

Many problems are sped up or slowed down in this manner so that their solution times are between 10 seconds and 1 minute.

Spring Problem

Another simple problem is that of a weight suspended on the end of a spring. Its equation of motion is

$$d^2x/dt^2 = -kx$$

Fig. 28 shows the computer setup for solution of this problem.

Special Computing Elements

Needless to say, problems that warrant use of analog computers are considerably more complex than those mentioned; many other components are available for special functions required in these complex problems. Diodes and other nonlinear elements are used to simulate limiting, backlash, or hysteresis. Tapped multiplier cups and diode function generators are used to produce nonlinear or empirical functions. Resolvers are used to produce sine and cosine terms, and to resolve rectangular to polar (or polar to rectangular) coordinates.

Error Detection

Many techniques may be used for checking results. The most commonly used method involves a check solution for a simple case of the problem. The test solution is run at the beginning and at the end of the problem. If the computing schedule extends over one or more weeks, the check solution may be run every three or four days. These check solutions are usually obtained by hand computation, and the examples are chosen to be as simple as possible to minimize the amount of hand computation necessary. In large analog-computing laboratories, solutions from digital computers are commonly used to check analog solutions. Some digital-computer groups have analog computers to check their digital computers.

Analog vs. Digital

People who are unfamiliar with computers are prone to ask: "Which is better, a digital or an analog computer"?

The answer is that neither is always better, the choice depends on the type of problem to be solved. A few problems require one-part-in-a-million accuracy and must be done on a digital computer. Ordinary problems should usually be solved on an analog computer because the accuracy requirements are not nearly so great.

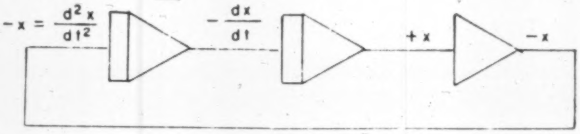


Fig. 28. Computer solution for spring problem.

Problems in which no more than 100 or 200 input quantities are involved can be done by analog computation, but for 1000 or more, digital techniques are indicated. Problems which require masses of tabulated output data should be done digitally; problems requiring graphical output usually are better suited to analog equipment.

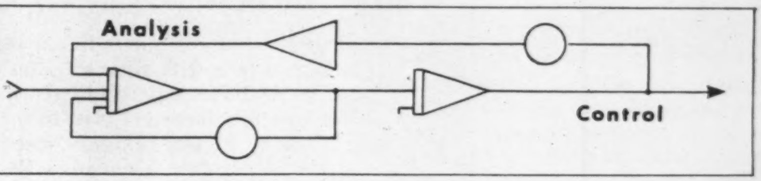
Computing Speed

One important advantage of the analog computer is its computing speed. As it performs all of its computing operations simultaneously (instead of sequentially as in a digital computer) the running time is independent of the size of the problem. On large problems the advantage is tremendous. One large analog-computing laboratory, which has acquired a digital computer for checking purposes, reports a speed advantage on some of their problems of over 100 to 1.

Conclusion

Today, the analog computer is becoming an integral part of every well-equipped engineering laboratory. It is finding more and more applications in the engineering and scientific fields, as well as in the process control and automation fields. It provides a new tool by which the plant engineer can see the results of equipment and controller installations or changes without costly experimentation. As is true throughout the field of industrial instrumentation, the power of each new instrument must be demonstrated by teaching the operating personnel. These articles have shown the simple elements of analog computers (attenuators, amplifiers, patch panel, etc.), the method for set-up and use of the computer, and the various techniques for solutions of problems.

The SIMULATION COUNCIL *Newsletter*



March 1955

Box 731, Camarillo, California

John H. McLeod, Jr., EDITOR

Suzette McLeod, SECRETARY

Western Simulation Council
Otis L. Updike, U.S. Naval Air Missile Test Center, Pt. Mugu, Calif.; Chairman, Steering Committee.

Midwestern Simulation Council
L. M. Warshawsky, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio; Chairman, Steering Committee.

Eastern Simulation Council
Harold K. Skramstad, National Bureau of Standards, Washington, D.C.; Chairman, Steering Committee.

HI!—to our old friends—and a more dignified "Hello" to our new acquaintances. If you are surprised to see the *Newsletter* here, we are astonished!

Our friends and subscribers—and these appellations do not necessarily mean the same people—may skip the next few paragraphs while we explain our presence to those who never heard of the Simulation Council.

We[1] are surprised (and honored) to be here because when I[2] first became interested in instruments and automation I was gaging tanks in Shell's NORCO refinery. Some of us there wanted to know more of the "why" of what we were doing, and *Instruments* (no Automation then) became our handbook. The "why" led me to join Taylor Instrument Companies, where I contended with the vagaries of control instrument applications. Then after a brief hitch in the Navy, during which time we (the USN) were not doing so well[3], I joined Leeds & Northrup in Research and Development. There I majored in design and minored in entomology, the latter so that I could cope with the bugs in the former. Then I came to California and became involved, willy-nilly, in analog computation and simulation. When I found that I knew nothing of this then-new field, I screamed for help. The Simulation Council was the answer.

The Simulation Council was formed in November, 1952 by representatives of organizations in search of a way to keep informed about improved techniques and equipment for simulation, and to minimize duplication of effort in the solution of common problems.

To accomplish this it was obviously necessary to improve communications. To this end it was decided that the Simulation Council would hold meetings to generate information, and publish a *Newsletter* to disseminate it.

The bimonthly meetings of the Western, Midwestern, and Eastern Simulation Councils have two objectives: to discuss aspects of simulation in which an outstanding interest has been shown, and to visit different simulation facilities. We believe that we can best direct our own efforts and improve our operational techniques by knowing what problems others face and what is being done about them.

The Newsletter is not a technical publication. It will not tell you how to solve your difficult simulation problems. We do, however, endeavor to create an environment better suited to the solution of these problems by improving communications. While recognizing their value, we do not publish technical papers. *Instruments and Automation* and other qualified publications do an excellent job in this area. The *Simulation Council Newsletter* concerns itself with the groundwork, the problems and *possible* solutions, the *people* and their half-baked ideas, and the sometimes haywire equipment that make these accomplishments possible. We try to tell you *who* is doing *what*, with *which* kind of equipment, and *where* you can find out more if you are interested.

One does not "join" the Simulation Council, but rather "participates" by attending meetings, subscribing to *Instruments and Automation*, or contributing information. We give manufacturers an opportunity to describe and demonstrate what is available, and allow the user to say what he thinks about it!

Our format will probab'y change from time to time as occasion warrants, or simply when we feel like a change. With this issue "Coming Events" has been deleted; the information formerly given under that heading will be found in "Events" elsewhere in this magazine.

After this introduction there will be "Bits"—the smallest units of information. This is the first section of our regular format, and is intended to give the reader an idea of what is to follow so that he can stop, skip, or read on as he sees fit.

Next comes "Pieces"—the pieces of information and comment which constitute the stories of our Simulation Council meetings.

Finally there is "Information (without Theory)" which, as the title indicates, is miscellaneous information which may or may not be relevant, and is thrown in for no better reason than that we found it interesting, or amusing, and hope you will.

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[1] "We" is the editorial we and here means Suzie and me.

[2] First person single, i.e. "B.S."—before Suzette.

[3] No correlation has ever been proven.

SIMULATION COUNCIL

BITS

As you have noted if you've read this far, this month's *Newsletter* is first concerned with introducing itself in its new environment. If you care to read further you will also find, under "Pieces", comments on the Louisiana State University High-Speed Computer Conference where your Editor spoke and urged the further use of computers in our technological race with Russia; notes on the Western Computer Conference by Dr. Otis Updike; and Saul Yochelson's story of the February meeting of the Midwestern Simulation Council at the University of Michigan.

Under "Info" we have some quotable quotes, a letter from one of our female readers, and assorted trivia.

PIECES

NOTES ON THE L.S.U. HIGH-SPEED COMPUTER CONFERENCE

When your Editor was invited to speak at the High-Speed Computer Conference held at Louisiana State University in Baton Rouge on 14, 15, 16 February, I thought this would be a wonderful opportunity[1] to talk on my favorite subject, the technical possibilities and the sociological effect of applying computer techniques to industrial problems—both in the plant and in the office. As my remarks elicited a good discussion, I considered the talk a success. However, there was only one thought which I expressed there and which I would like to repeat here. It is, that with Russia turning out engineers at a rate estimated from three to five to our one—and there is no reason to believe that they are not good ones—to maintain our very existence will require that we use our engineering manpower three to five times as effectively as they do. Computers can help.

Applied to industrial processes computers can improve and extend automation and thus free operating engineers for creative work. And they can increase the effectiveness of engineers already doing creative work, not only by relieving them of routine time-consuming computations, but by making it possible to solve problems heretofore impractical or impossible to handle. Finally, as powerful tools of management, computers can help increase the efficiency of plants and thus the effectiveness of the engineers they employ.

We will not attempt to report on the other talks at the Conference because they were (except for one by H. M. Martinez of Berkeley Scientific Division of Beckman Instruments, Richmond, Calif., on "Operational Equations for Programming Electronic Analog Computers") all concerned with business procedures and/or digital computers.

We were surprised at the interest in high-speed computers in that part of the country. There were some 366 persons registered. The great majority were from Louisiana, and nearly all the rest from neighboring states. We were also surprised at the banquet. Instead of tired fried chicken, delicious filet mignon, good as we've ever tasted. And after this the speaker, Tudor Finch (Assistant Vice-President, Bell Labs), did an unusually good job of entertaining and informing.

A tour of the Standard Oil Company refinery was also of interest and well handled. We were particularly interested in the control room for one of the latest units just going on stream. All instrumentation was embodied in two of Albert Sperry's Panellit graphic panels. Boy, that's the way to do it! What an improvement over the control rooms of my oil refinery days.

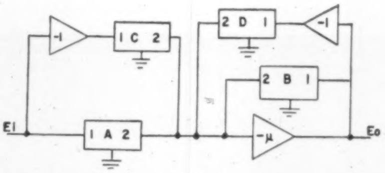
NOTES ON THE WESTERN COMPUTER CONFERENCE AND EXHIBIT

By Dr. Otis Updike

J. P. Eckert, Jr. sounded the keynote of rapid progress in the opening session of the Conference on March 1st. Contrasting the luxurious time scale of Leibnitz and Babbage with the pace of modern developments, he outlined some of the needs and prospects of the computer field in the next five to ten years. Some needs of digital machines apply to analogs as well—e.g., a standardized terminology to describe performance. When the transistor-magamp revolution is further along, we will find need for more reliable components of all types: resistors, capacitors, even connectors. An intriguing idea of Eckert's was a rating of computers as "calorie-spenders."

Mathews and Seifert on Synthesizing Transfer Functions

Mathews and Seifert (both of MIT) opened the second day's analog session with a development of methods of synthesizing transfer functions on an electronic differential analyzer. One method, worked out by Beck at NAES and described in the first Cyclone Symposium, develops the function as a quotient of two polynomials in s by the use of a cascade of integrators with feedback and feedforward loops whose gain sets the coefficients independently in numerator and demoninator. The second method, newly reported by Mathews and Seifert, uses four networks and three amplifiers, in the circuit sketched.



With these, poles can be placed anywhere on the negative real axis, and zeros anywhere in the complex plane. Economy of components favors the use of the Mathews-Seifert synthesis where there are more than about two zeros and three poles. In many practical cases, as the authors demonstrated, the networks of the three-amplifier setup reduce to two-terminal types, and one amplifier of the three may not be required.

Irvine and Davis on Multidimensional Filters

Irvine and Davis (both of Aerojet-General, Azusa, Calif.) then described some of their work in multidimensional filters, where they have simulated complex field distributions by modeling. Their problem is the recovery of "messages" from a noise field of two or more spatial dimensions. For example, to discover a spot of high energy in a two-dimensional noise field, they scan the field optically with a shaped filter. Half of the filter disk is solid, the other half sectorally masked. As the disk is rotated a signal is generated whose amplitude and phase permit detection and location of the target. The studies of this technique have been carried out analytically with n-dimensional Fourier transforms and experimentally with an optical-electrical-mechanical modeling system.

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[1] It was also a wonderful opportunity to take in the New Orleans Mardi Gras. We were *not* involved in those riots!

MacNeal and McCann on Ideal Transformers

MacNeal and McCann (both of California Institute of Technology, Pasadena, Calif.) next described the role of ideal transformers—which can be approximated to well under one percent for about a kilobuck apiece—in direct network analyzers, "McCannalogs"! Input data for these analyzers come in as system descriptions, equations, test results, or as a combination of these forms. For representing mechanical systems, a nodal analogy is attractive, partly because its topological isomorphism (structural similarity) to the mechanical system eases the problem of setting up an analog from a system blueprint. Without transformers the equations represented would be restricted to constant, real coefficients. With transformers, coupling of modes can be represented, and the simultaneous equations required for coordinate transformations can be instrumented. These properties are invaluable when direct test data are to be used in synthesizing a system since coordinate transformations are required whenever there are fewer mechanical restraints than there are terminals of the network.

C. M. Edwards on Grounding Technique

C. M. Edwards (Bendix Aviation Corporation Research Laboratories, Detroit, Mich.) discussed a new grounding technique for electronic differential analyzers. Since Goldberg introduced chopper-stabilization to reduce drift errors to 0.1 to 1 mv, ground currents have become a controlling source of error which cause offsets of 1 to 10 mv in large installations. Three types of ground currents exist: signal (from pots, etc.), cathode, and chopper return. Conventionally, signal currents have been provided with a separate grounding system, whereas cathode and chopper currents have been grounded together through a bus system heavy enough to suppress crosstalk. The Bendix people adopted a separate chopper-ground bus and used separate grounding leads for each of their pots. In an installation of some ten computing cabinets, these methods held the offset of the chopper ground to 0.1 mv, while affording a large saving in copper over the conventional brute-force methods.

Mazelsky and O'Connell on Digital-vs-Analog

The passing of the digital-vs-analog issue was pointed up in a paper by Mazelsky and O'Connell (both of Lockheed Aircraft). Having electronic differential analyzers, direct network analyzers, digital differential analyzers, and general-purpose digital machines available, they described the advantages and disadvantages of each type in preliminary design, shake test, and final analysis problems. Recommended was a symbiosis of all types of approach to get the advantages of each and to allow cross-checks between the different methods.

Wadel and Wan on Aircraft Performance

Wadel and Wan reported a program of aircraft performance studies which they are making at Chance Vought. They have set up some 35 nonlinear functions, using drums and algebraic approximations, to represent the aerodynamic, power plant, atmospheric, geometrical, and weight characteristics of various aircraft on a mission. They plan a series of programs of speed and power for optimum climb and cruise, length of stay at destination, etc., to give a mission of minimum time or minimum fuel consumption. By appropriate level-detection methods, they can set up their REAC to perform automatic trial-and-error calculations and come out with data suitable for the pilot's handbook.

Selfridge on Combination Technique

Selfridge (Naval Ordnance Test Station, Inyokern, Calif.) described the technique he is using to combine some of the virtues of analog and digital machines. Buying accuracy at the expense of speed, he has coded an IBM 701 to act like an electronic differential analyzer. He finds that the cost during problem solution favors the analog ten to one, but when the time includes setup and checking, the digital often wins! Elimination of inverters and consistency of digital errors were cited as advantages; "when a digital machine makes a mistake, it's more exactly wrong than an analog." On problems which a digital differential analyzer can handle, the DDA gives ample accuracy at higher speed than the analog-coded 701, but the DDA is somewhat small and specialized. Asked if this had made their REAC obsolete, Selfridge replied, "No! I set up a problem on it just last week."

Exhibits

Among the exhibits, your reporter was impressed with Beckman's push-button setting of pots and particularly their new diode function generator. EASEy to set, this EFG is based on silicon-junction diodes instead of old-fashioned thermionic diodes. Other impressions included the popularity of the Electronic Associates exhibit (where at least one visitor was getting a problem run for free—one way of relieving the overload on your facility!); the unexpected absence of Reeves; and the massive infiltration of the digital field by transistors and magnetic cores. The small power requirements of some transistorized subassemblies approach fantasy!

In a sampling of a few non-analog papers, the session on learning machines put on by MIT and the Rand people really stood out. With the number of decision elements now available in large digital machines, it is becoming possible to program pattern recognition and even to make a system organize itself to perform different simple tasks depending on the organization present in its inputs. The difference in approach between these digital devices and Irvine's space filters for pattern recognition is interesting; the digital devices are now much cruder and slower, but they seem to be unlimited in what they can do if enough elements (and enough time) are available.

The question asked most often at the meeting was "What type of shop, open or closed?". All answers seemed to apply to a particular installation. Some groups limit computer operation to their staff of specialists, some encourage all their engineers and scientists to set up their own problems, and some follow a middle course. And all the methods work if they are administered well.

NOTES ON THE MIDWESTERN SIMULATION COUNCIL MEETING

By Saul Yochelson

The fourth meeting of the Midwestern Simulation Council was held in Ann Arbor, Michigan on 21 February 1955. Our host, the University of Michigan, invited visitors to inspect the analog-computing facility in the Department of Aeronautical Engineering before the meeting.

Bob Howe on Partial Differential Equations

The subject of the meeting was "Machine Solutions of Partial Differential Equations." Bob Howe (University of Michigan, Ann Arbor), as first speaker, noted that partial differential equations occur in a great many physical problems—for example, almost all problems involving continuous media, wave media, wave propagation, or elasticity. In general, partial differential equations involve two independent variables, such as distance and time, while ordinary differential equations involve only one independent variable. As the electronic differential analyzer can only integrate with respect to time, some means of handling the integrations with respect to the second variable must be devised.

Two techniques are commonly used: (1) The method of "Separation of Variables" and (2) "Finite Difference Equations." The first technique depends on separating the equations into products and, in general, leads to eigenvalue problems. The solutions are the "normal modes" which must be combined in Fourier series to give the complete solutions. This technique is fairly simple but requires a great deal of equipment, and is used only for the solution of linear partial differential equations with fairly convenient boundary values.

The second method of solving these equations uses finite-difference equations. The solution is considered in terms of one variable with the other fixed at a number of "stations." One set of derivatives becomes differences and the result is a set of simultaneous differential equations which can be solved on an ordinary differential analyzer. This approach converts a distributed system to a lumped-parameter system. The equations usually can be solved by either analog or digital methods, and if analogs are used, either a direct analogy or a differential analyzer may be used. Typical problems which have been solved using direct analogies are simple heat-flow problems, wherein the individual elements may be represented as simple R-C networks. Even so, it is difficult to read out the answers and the computer is not very versatile. In more complicated problems, simple R-C networks are no longer adequate, and transformers must be used. Also, unloading amplifiers are frequently needed, so before long, the problem setup becomes no simpler than that of an electronic differential analyzer.

When nonlinear partial differential equations are involved, it almost always is necessary to use electronic differential analyzers because it is difficult to mechanize the arbitrary nonlinearities in a direct analogy circuit. In the Aeronautical Department of the University of Michigan, a number of nonlinear partial differential equations have been solved. These have included nonlinear heat flow equations in which the heat conductivity was a nonlinear function of temperature, and also structural and dynamic problems where nonlinear stress-strain relationships are involved. The electronic differential analyzer is a useful tool in this type of problem but it takes a fair amount of equipment. In general, it takes at least one nonlinear element per cell (or station) per nonlinearity of the problem.

When dealing with lumped-parameter representatives of continuous systems on the analog computer, it is obviously important to know how many stations are required to achieve a given accuracy. This problem was looked into rather carefully from a theoretical point of view and the results show that surprisingly few stations are required. For example, in a heat-transfer problem in a slab between two boundaries where the initial temperature distribution inside the slab is not too "nasty" three, four, or five stations are all that are needed inside the slab to achieve accuracies of the order of several percent. Therefore it can be seen that in the one-dimensional case the problem can be solved practically.

With two-dimensional problems the amount of analog equipment required begins to get out of hand. Three-dimensional systems solutions using differential analyzers are probably impractical at present state of the art.

Bob said that one thing which surprises people is that at the University of Michigan they even consider analog solutions when so much digital equipment is available. The answer is that most of the problems encountered in engineering practice can be handled better on analog machines. In particular, problems involving dynamics can usually be solved a lot faster and more economically on an analog machine.* Also, real-time simulation is frequently important. The solution of the real-time characteristics of a system requiring a partial differential equation for its description almost forces an analog type of representation. For example, where a process control system is being designed and where the process being controlled involves heat-transfer equations, in order to mechanize in real time, it is almost necessary to go to an electronic differential representation of the system. In case of aircraft, most people now know that it is inadvisable to design aircraft controls considering the aircraft as a rigid body; it is increasingly important to consider the elastic characteristics of the airplane. It is also convenient in testing a control system to be able to simulate the elastic characteristics in real time or perhaps at some reasonable time scale.

Professor Howe's Comments

Summarizing, Professor Howe said that there are obviously some places where digital computers are more useful, others where the analog computer is more useful, and that there is certainly a reasonable overlap.

Asked what the basis was for deciding how many cells were required for a partial-differential solution, Howe said that in this investigation, typical problems were selected and solved exactly by separation of variables. Then the difference equation representations which would be set up on the computer were solved exactly (not on the computer). Normal mode shapes and decay constants were compared with the calculated values as obtained from the exact continuous solutions. As solutions can be thought of as super-positions of the normal modes, if the normal mode shapes

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*See the notes on the Western Simulation Council meeting of 17 March in next month's *Instruments and Automation* for the other side of this question.

were correct and the mode frequencies were correct, then the difference equations were approximately correct. From the errors as a function of the number of cells, the number of cells required to solve typical problems was determined. Professor Howe, with a simple example, showed how the solution at successive increments of time of a simple heat-flow problem can be thought of as a number of sinusoidal solutions superimposed in a Fourier series, each solution having a different decay time. The solution of linear differential equations with simple boundary conditions can be thought of as the superposition of the normal modes which result from separation of variables, where the first mode is almost always the predominant one. If the normal modes which occur when the system is broken up into a lumped-parameter system have the same shapes and the same decay times as the continuous normal modes, then when the whole thing is put together the solutions will be accurate. From the required accuracy of mode shapes and decay times, the charts which have been prepared show the number of stations needed. Work has been done on problems in radial and spherical coordinates, as well as rectangular coordinates.

Professor Howe pointed out that many times when the solution varies very rapidly in some regions and not so rapidly in others, it would appear advisable to space some of the stations close together and others farther apart. They have found that if the stations are located arbitrarily, the accuracy is not very good. If an analytic transformation is made—that is, a new variable such as Z^2 substituted for X—and the stations are located at equal values of Z, increased accuracy may be obtained. Similarly, in problems involving partial differential equations in semi-infinite media (for example, heat flow in a bar, one end of which is embedded while the other end goes to infinity), where a "large" number of stations would be required, transformations can be made which map the region from 0 to infinity into the region from 0 to one, in this case, $Y = 1 - e^{-X}$. Equal stations in Y correspond roughly to equal stations in X at the beginning but gradually spread out until the ninth station, for example, corresponds to X equals infinity.

A question was asked about the widely different gains which result for the inputs to the amplifiers when difference techniques are used; i.e., the coefficients may differ by several orders of magnitude. Howe said this was normal and the variation is just what is needed to represent the problem. This sometimes can cause trouble.

Michael Yanovitch on Flutter Analysis

The second speaker was Michael Yanovitch (Reeves Instrument Company, New York City) who discussed the application of analog computers to flutter-analysis problems. The Galerkin method leads to a large number of integrals and, when something like the mass of a fuel tank is changed, most of the integrals must be recalculated. Difference equations are simpler because changing of location or size of masses affect only a few terms. The particular problem which Mr. Yanovitch described was done at Project Cyclone. Difference equations techniques were used but the data available were in the form of a matrix of inference coefficients. (The problem involved a swept-back wing of a plane.) The inference coefficients represented the deflections at the different stations for unit forces located at the various points. The matrix was inverted, giving a set of difference equations representing the system. The particular problem involved led to a 14 x 14 matrix. To solve this, a 14 x 14 potentiometer matrix was built up. Only plus and minus variables were needed as inputs for the matrix to furnish an output. It turned out that the output of the matrix was very small; on the order of one tenthousandth of the input voltage. This was not too serious a difficulty in this flutter problem because all that was needed was the speed at which the flutter became sinusoidal, but it could become serious in some types of problems (such as those concerning boundary values). This particular problem used about five REACs. (Your reporter got pretty lost in the discussion following this talk.) Professor Howe pointed out that if the problem can be solved from the equations using second differences of second differences, much better accuracy can be obtained than by taking the fourth differences directly as must be done when the matrix method is used. In the latter case component tolerances on the computer become serious (small errors in component values can cause serious errors in the solution).

Paul Hermann on Heat Transfer

After intermission, Paul J. Hermann of the Goodyear Aircraft Corporation described a heat-transfer problem solved by the Computer Lab at GAC for another division of the company. The problem involved calculation of temperature gradients through the thickness of a plastic window of an aircraft.

It was necessary to solve this problem on an electronic differential analyzer because a number of nonlinearities were involved.* These were nonlinear heat-transfer coefficients, nonlinearities in the outside air temperature, and the fact that there were different layers of different materials making up the window. The problem was essentially that of a windshield consisting of an outside layer of plastic, an airspace, and an inside section broken into three layers. The outside air temperature varied arbitrarily with respect to time, and in addition, the heat-transfer coefficient from the outside air temperature to the first layer was a nonlinear function of temperature. As the computer lab had not participated in many problems of this type before, a good deal of the work was done by aerodynamic engineers who were not familiar with computers. This was one of the reasons that troubles were encountered. Paul showed and explained the equation, the method of breaking it up into finite difference equations. He also showed a circuit diagram of a typical part of the computer setup for the problem. Basically, the nonlinear functions were simulated with function generators and an amplifier was used for each station of the problem. This resulted in a number of positive feedback loops, but the gain of each loop was less than one. The question of how many stations to use in setting up the problem was solved simply: only 20 integrators were available at the time, and since one integrator was needed per station, 20 was the number of stations. Once the problem was set up the main difficulty was that accurate components were needed. Paul had one bit of advice to the other people who might have occasion to set up this type of problem: "Do not hurry!" Professor Howe pointed out that improved accuracy can frequently be obtained by using three ampli-

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*Not because Goodyear makes electronic differential analyzers!

The Second International

AUTOMATION EXPOSITION

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fiers per cell rather than one.* Following Hermann's talk most of the group went to the Willow Run facilities of the University of Michigan and inspected the digital and analog computers there.

All in all, the meeting was both interesting and informative. Except that 21 February was Election Day in Michigan (as a result nothing stronger than wine could be found anywhere) everything was nicely handled by Professor Howe and Company.

---

*You selling equipment now, Bob?

INFORMATION (WITHOUT THEORY)

Herewith a few interesting remarks picked up by Otis Updike at the W.C.C.

Pres Eckert: "You can't check a computer into being reliable."

Simon Ramo: "In automation, you look at a problem as you're doing it now and as you'd like to do it; then you put in the difference between the methods."

Norm Irvine: "Whether it's digital or analog, addition is the only really successful operation we've learned to do with computers."

And a simile I like, which I get from Fred Sturm: "A computer to an engineer is like a tool to a craftsman. A really good craftsman can often do a good job with poor tools, whereas a mediocre craftsman *must* have good tools. But a really good craftsman with really good tools can do the apparently impossible."

And another from "Electronics Down To Earth".[1] Having indicated that most business data are, by the time they become available, of historic interest only, they state: "In a real sense management has been driving down the business highway, using only the rear-vision mirror."

And didya read what the late great anthropologist Ernest A. Hooton had to say in "The Human Animal in the Machine Age"[2]? "The inventor does indeed draw upon accumulated knowledge, so the machine benefits by cultural tradition. Machines are nothing more than projections of human intelligence." What a projection!

---

[1] John A. Higgins and Joseph S. Glickauf in *Harvard Business Review*

[2] *ISA Journal*, June 1954

PERSONALS

We also want you to read a letter we received recently, so here 'tis:

> Dear Editor:
>
> The December issue of the *Simulation Council Newsletter* reached my desk in the Dynamic Systems and Computation Laboratory (DSCL) of Goodyear Aircraft Corporation today. In regards to your parenthetical comment—"(do any ladies read this sheet?)"—we certainly do!
>
> There are six ladies in the DSCL with classifications of computist, mathematician, and simulation engineer. We all read the *Newsletter* and find it interesting and informative. Keep up the good work!
>
> Sincerely,
> Marjorie L. Finley
> (Mrs. Charles L. Finley)

It's things like this that keep us going, even when they are not so flattering. May we have *your* comments?

Address favorable ones to Instruments Publishing Co., 845 Ridge Avenue, Pittsburgh, Pennsylvania. But for gosh sake don't let Rimbach or Aronson see the unfavorable ones. The latter kind should be addressed to:

John McLeod
Box 731
Camarillo, California

Or maybe to be safe you'd better address them all to me. I like my new job.

The *Simulation Council Newsletter* will be a regular monthly feature in *Instruments and Automation.*

Process Control Analysis

This begins a new series on a subject of current interest and vital importance in the process control field. The process and the controller must be considered as a unit in analysis of the control problem. Simple equations show the effect of each element in the process. This analysis is basic to an understanding of the technique required for optimum control practice.

MILLARD H. LAJOY
University of Minnesota
and
E. ALLEN BAILLIF
Seeger Refrigerator Co.

INDUSTRIAL PROCESS CONTROL is becoming one of the most important and challenging activities in the engineering profession. Although its history has been comparatively short, it has included remarkable feats in the development of many industrial processes. In today's industry the call for high-speed production has resulted in almost unheard of productive rates, or throughputs. The dual demand for high quality and fast production has placed a severe burden on the automatic controller.

Faced with today's ever-increasing automatic-production problems, the time is arriving when more thought must be given to the design of the process and controller *as a unit*, thereby enabling a simplified controller to be applied economically, with as few adjustments as possible. In addition, many industrial processes may be made easier to control if certain judicious choices and adjustments in the process are made in the design stage. This is something that occurs all too rarely, and hence, in current practice, a wide range of adjustments must be available in the controller.

There is a need for a method of analysis that can be used in the field of automatic control today which does not lose sight of the physical system itself. The objective in this and succeeding chapters is to develop an analytical method of approach to the problems associated with automatic control systems. Although some of the equations may appear difficult, we should understand that this is primarily because of their comparative length. Once the numerical values of the process constants are substituted, they reduce to much simpler expressions. There is a definite advantage in setting up the system equations in a general way, even though they become unusually long, because it allows us to catalog solutions that may have future value in studying other processes which are analogous mathematically.

The method to be presented treats each component of a control system as an individual resistance and capacitance stage, develops simple equations for each component, and combines these to form a complete equation representing the system. This first chapter is concerned only with the process equation. It is expanded as far as a three-capacity system. The equations developed will be representative of both simple and complicated processes. Systems which are still more complex can be developed in an analogous manner. Likewise, systems involving parallel resistances and capacities can be synthesized by the same procedures.

The Process Equations

Plant operations or manufacturing procedures that utilize automatic controls will be classified generally as processes. They may be simple or complex. As this study is concerned with the mathematical analysis and synthesis of the controlled process, it will be necessary to express first the process in mathematical form.

For the purpose of deriving the process equations, a liquid-level system will be employed. There is no loss in generality in this choice of process because other proc-

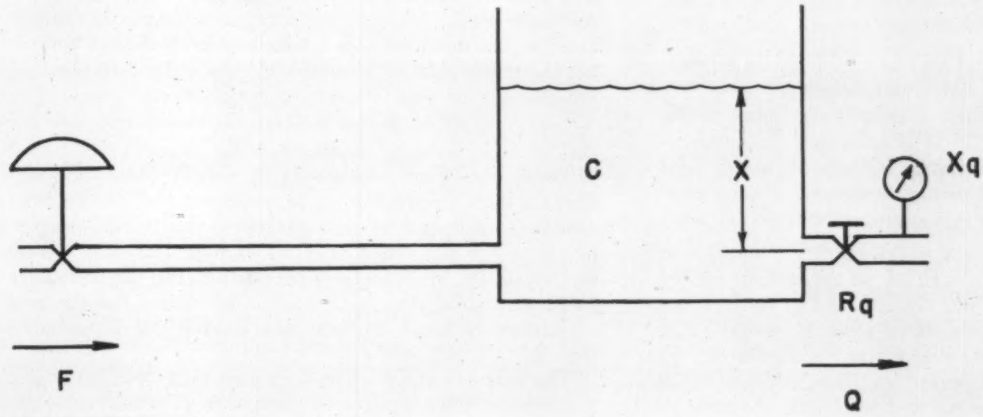


Fig. 1-1. Single-capacity liquid-level process.

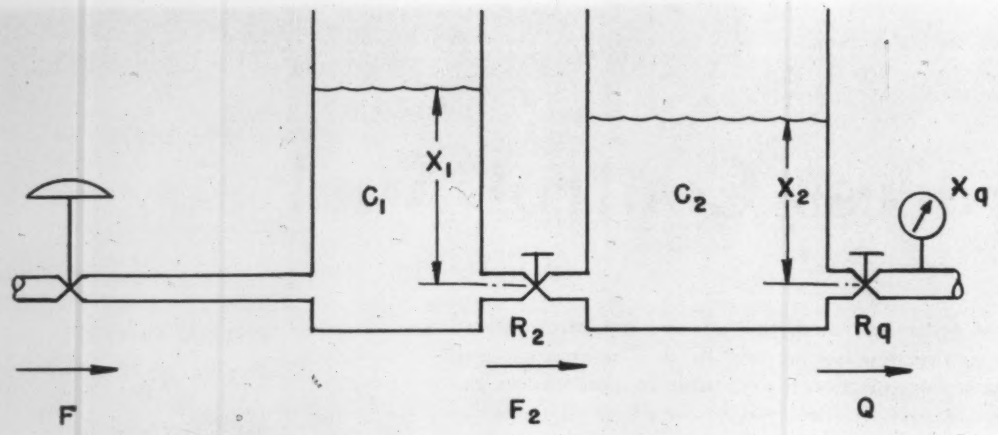


Fig. 1-2. Two-capacity liquid-level process.

esses, such as temperature or pressure, would yield identical mathematical equations.

First, it is necessary to decide on a standard system for representing the processes. The most readily applicable system is that of representing the processes by a number of capacities and resistances, or, in other words, by two types of units, one which has the ability to store energy, liquid, pressure, or whatever the process medium may be, and one which restricts the flow of the "substance" between the various capacities. They will be represented by "C's" and the "R's" respectively in the developments which follow (Fig. 1-1). The symbol "x" with an appropriate subscript will be used to denote the potential or level in each capacity. The symbol "x_q" will be used to signify the potential to which the outgoing flow is discharged. Values of the R's and C's will be assumed to be constant.

Single-Capacity Process

The basic elementary system is a single-capacity process. Fortunately, this type is found in practice and, therefore, is a representative one to study.

A liquid-level system of one capacity is shown in Figure 1-1; the various quantities have dimensions as shown in Table 1.1.

Table 1.1—Symbols and Dimensions for Liquid-level-type Process

	Symbol[1]	*Dimension*
Level or Potential	x	ft
Flow	F and Q	cu ft per min
Capacity	C	cu ft per ft
Resistance	R	ft per cu ft per min
Time	t	minutes

[1] Subscripts are used with symbols to further identify the quantity for each particular application example.

Capacity of a symmetrical tank is calculated as follows:

$$C = \text{volume of vessel/height}$$

Resistance to flow through a restriction (such as the outlet resistance of Fig. 1-1) is as follows:

$$R_q = (x - x_q)/Q \qquad 1.1$$

This is simply Ohm's Law for flow.

Single-capacity Process Equation

The equation describing a single-capacity liquid-level process can be obtained by writing an expression for the rate of change of level when the inflow and outflow are unequal. A disturbance in outflow level x_q would cause these flows to be different. For a fixed disturbance, the two flows would, after a period of time, become equal again. Immediately following a disturbance the rate of change of level (dx/dt) would be directly proportional to the difference between the inflow and outflow, and inversely proportional to the vessel capacity, C. This can be expressed mathematically as follows:

$$dx/dt = (F - Q)/C \qquad 1.2$$

Solving equation 1.1 for Q and substituting this result into equation 1.2 and rearranging, we obtain:

$$(1/R_q)\ (H dx/dt + x) - x_q/R_q = F \qquad 1.3$$

where

$$H = R_q C \qquad 1.4$$

Equation 1.3 *is basic for all single-capacity processes of the type shown in Fig.* 1-1. Note that it is a first-order differential equation. It has been derived in terms of the process constants of resistance and capacity, the outflow head x_q (which will be treated as a source of disturbance to the system) and the inflow, F. At present we are not concerned with the effect of changes in inflow. Later, when the automatic controller is included, it will be found that an expression can be written for "F" in terms of the level, x, which will be selected as the variable to be controlled.

Two-Capacity Liquid-Level Process

A two-capacity liquid-level process is shown in Fig. 1-2. The dimensions represented by the various symbols are the same as in Table 1.1. Subscripts identify the location of the process quantities (flow, resistance, capacity, and level). The inclusion of a second capacity results in a more-complicated process equation. However, the development of the mathematical expression for this process is straightforward and can be followed without difficulty. It is only necessary to repeat the steps that were followed in obtaining the single-capacity-process equation 1.3.

Development of Two-capacity Process Equation

Referring to the two-capacity process of Fig. 1-2, we can write expressions for the flow between the vessels and the outlet flow in the following manner. When a disturbance occurs in a process, such as a change in outflow head, x_q, all the flows will be unequal immediately following the disturbance. The expressions for the flow between vessels and the exit flow are, respectively:

$$F_2 = (x_1 - x_2)/R_2 \qquad 1.5$$

$$Q = (x_2 - x_q)/R_q \qquad 1.6$$

These equations (Ohm's law) simply state that the flow through a restriction or a resistance (which has been assumed as linear in our analysis) is directly proportional to the difference in level, or potential drop across the resistance, and inversely proportional to the resistance itself. Our next step is to write expressions for the rate of change of level in each tank during the disturbance period.

The *rate of change* of level in each tank is directly proportional to the net inflow or outflow from it, and inversely

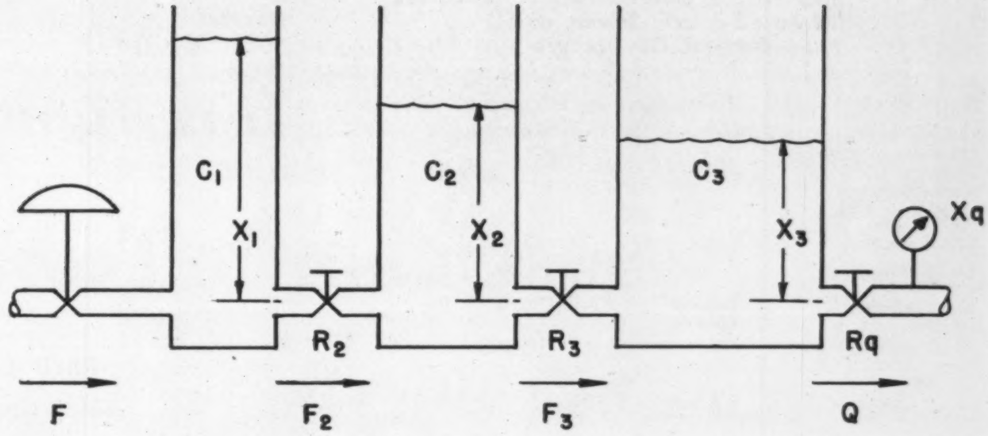


Fig. 1-3. Three-capacity liquid-level process.

proportional to the capacity of the vessel, respectively. Thus:

$$dx_1/dt = (F - F_2)/C_1 \qquad 1.7$$

$$dx_2/dt = (F_2 - Q)/C_2 \qquad 1.8$$

Equations 1.5 through 1.8 provide all the necessary relationships for obtaining a single equation in terms of tank level x, inflow F, disturbance level x_q, and the process constants of resistances and capacities. The equation could be derived either in terms of the level in the first tank or the level in the second tank, whichever is desired. Assume that it is the level in Tank 2 (x_2) in which we are interested. Later, we will discuss an application of an automatic controller to maintain the level in Tank 2 at some desired value. After applying algebra to Equations 1.5 through 1.8 inclusive, we obtain the following expression:

$$\frac{1}{R_q}\left(J_2\frac{d^2x_2}{dt^2} + J_1\frac{dx_2}{dt} + x_2\right) - \frac{x_q}{R_q} = F \qquad 1.9$$

where

$$J_2 = C_1C_2R_2R_q \qquad 1.10$$

$$J_1 = C_1R_2 + C_1R_q + C_2R_q \qquad 1.10$$

Equation 1.9 is the final process equation for a two-capacity system of the type shown in Fig. 1-2. The addition of a second capacity results in raising the order of the equation from first to second.

Three-Capacity Process

As our final consideration of processes, we will consider a three-capacity system (Fig. 1-3). The various quantities are as identified in Table 1.1. A three-capacity process is representative of a complex system to control. The equation that describes such a process will be a third-order differential equation.

It can be derived by following the identical procedures used to obtain the process equation for a single- and two-capacity process.

Assuming a disturbance occurs in the process by a step change in outflow head, x_q, the flows between the various vessels and the outflow are as follows:

$$F_2 = (x_1 - x_2)/R_2 \qquad 1.11$$

$$F_3 = (x_2 - x_3)/R_3 \qquad 1.12$$

$$Q = (x_3 - x_q)/R_q \qquad 1.13$$

The *rate of change* of level in each vessel is:

$$dx_1/dt = (F - F_2)/C_1 \qquad 1.14$$

$$dx_2/dt = (F_2 - F_3)/C_2 \qquad 1.15$$

$$dx_3/dt = (F_3 - Q)/C_3 \qquad 1.16$$

Equations 1.11 through 1.16 can be combined to obtain a single equation in terms of any one of the tank levels (x), the outlet level (x_q), the inflow (F), and the process constants of resistance and capacity. A comparatively large amount of algebra is necessary in the combination of the above equations to obtain a single expression, which will be called our process equation. It is necessary to decide the tank level in which we are primarily interested. We will select tank level 3, x_3, as the location of primary interest. Determinants were used in deriving the final process equation for the three-capacity process:

$$\frac{1}{R_q}\left(K_3\frac{d^3x_3}{dt^3} + K_2\frac{d^2x_3}{dt^2} + K_1\frac{dx_3}{dt} + x_3\right) - \frac{x_q}{R_q} = F \qquad 1.17$$

where

$$K_3 = C_1C_2C_3R_2R_3R_q \qquad 1.18$$

$$K_2 = C_1C_2R_2R_3 + C_1C_2R_2R_q + C_1C_3R_2R_q + C_1C_3R_3R_q + C_2C_3R_3R_q$$

$$K_1 = C_1R_2 + C_1R_3 + C_1R_q + C_2R_3 + C_2R_q + C_3R_q$$

Equation 1.17, with values of the constant K coefficients as given in Expressions 1.18, is the final process equation for a three-capacity system. It is representative of all three-capacity systems of the type shown in Fig. 1-3. The process resistances and capacities are being treated as constants in our analysis. Therefore, once the numerical values of these are known and substituted in relationships 1.18, the values of K_1, K_2, and K_3 will be numerical numbers.

The three relationships given in 1.18 are extremely valuable in determining how these coefficients can be altered by varying the sizes of the vessels and the restrictions or resistances to flow. Note that there is considerable interaction of resistances and capacities and that these coefficients are not simply derived. It is not possible to change one coefficient without affecting another. In the analysis of systems, it will be found that the relative magnitude of the various coefficients is the important factor which determines the characteristics of the system. This will be treated in greater detail when we include the automatic controller in the system.

Conclusion

A procedure for obtaining the process equation has been shown because it is the physical system itself that must be altered to obtain best control performance. The methods followed are simple, direct, and full of tangible significance. The next step is to include the automatic controller in the physical system. The automatic controller will include the measuring element, the signal transmission lines, and the final control element which regulates the inflow to the process.

(*To be continued*)

Investigation of

Temperature

FRED E. DICKEY
General Electric Company

Table 1.—Temperature Coefficients of Inductors with Fused-quartz Forms and Bonded-metal Conductors

Inductor	*Maker*	*Form*	*Temp. Coeff. in ppm/°C*
13.7 μh, 2.7-in. dia. x 3.75-in. long; 19 turns; 0.005-in.-thick conductors; Q = 50 at 2 Mc.	Thomas[6]	Fused Quartz	15
3.5 μh solenoid	a N. Y. Laboratory	Vicor	24
1.3 μh flat spiral	a N. Y. Laboratory	Fused Quartz	30
7.1 μh solenoid; 1-9/32-in. dia. x 2-5/16-in. long; 23 turns; Q at 10 Mc. = 210	General Electric	Fused Quartz	19
7 μh solenoid	General Electric	Pyrex	17
27.7 μh, 2.9-in. dia. x 2¼-in. long; 22½ turns; solenoid Q = 133 at 5.5 Mc. and 86 at 2 Mc.	General Electric	Fused Quartz	13

(Note: μh represents microhenries)

BASIC NEED in electronic and electrical engineering is for zero-temperature-coefficient inductors. Although compensation can be made with negative-coefficient capacitors, the frequency of such tuned circuits may vary erratically under transient temperature conditions. Many efforts have been made to use fused-quartz coil forms because such forms are extremely stable. However, use of fused quartz as the coil form with bonded metal conductors (so that the conductors can not expand more than does the form) does not result in an extremely low temperature-coefficient of inductance (Table 1).

These inductors do not exhibit sufficiently low coefficients to warrant the expense and difficulty of their construction for most purposes. (However, they do exhibit excellent long-time stability; in all cases they returned to the same value of inductance and exhibited almost no hysteresis during temperature cycling.)

The basic reason for the high coefficients in inductors which do not change size with temperature is that part of the total inductance comes from current flowing inside the conductor. The depth of this penetration varies with the conductor's resistance, which has a high temperature coefficient. As the temperature changes, the resistance changes rapidly, which means that the amount of current inside the conductor (and, therefore, the component of inductance it causes) also changes at a high rate. Although this component, called *internal inductance*, is small, its contribution to the over-all inductance coefficient is large because it changes so rapidly.

The only way that this inductance coefficient can be minimized is to use conductors which are very thin compared to the depth of penetration, or which have low temperature coefficients of resistivity. Unfortunately, the former means high-resistance coils, and only resistance wires such as nichrome have low resistivity coefficients.

Investigation of Technical Literature

If a coil of wire which is free to expand in all directions is heated, its inductance theoretically should increase by a temperature coefficient at least equal to the temperature coefficient of linear expansion of the wire. That this is not true is well known and has been borne out by experiments; many investigators have tried to find experimentally and mathematically why this is so. Some worked with coils which were free to expand in all directions on high-expansion forms; some tried high-resistance conductors; others tried to bond the conductors to low-expansion forms. However, all results showed temperature coefficients of inductance that were at least twice the temperature coefficient of linear expansion for freely expanding coils, and unpredictable for bonded types.

The following discusses in chronological order the work done by various authorities in an effort to explain this discrepancy between theory and practice.

Moullin[1] calculated the temperature-inductance characteristic of a conventionally shaped coil in which axial expansion differed from radial expansion, but in which the shape of the turns remained circular. He pointed out that if the coil was free to expand radially, but held to a constant length, the temperature coefficient of inductance would be twice the coefficient of linear expansion of the conductor. This does not, however, explain why this is so for coils which are free to expand in all directions, nor does it explain the high inductance coefficients found for coils firmly attached to low-expansion forms.

H. A. Thomas[2] reported the results of tests on a large number of single-layer coils and showed that the temperature coefficient of inductance was, as before, at least twice the conductor's coefficient of linear expansion. He attempted to explain the large coefficient by attributing it to *self-capacitance changes and small changes in dimensions*. He derived an expression for the temperature coefficient of inductance as follows:

$$\partial = (a + \omega^2 LC\delta)/(1 - \omega^2 LC) \qquad (1)$$

where L = self inductance of coil
C = self capacitance of coil
a = temp. coeff. of linear expansion of form
δ = temp. coeff. of dielectric constant of form
$\omega = 2\pi$ (frequency)

This assumed an absolutely tight bond between form and conductor. Thomas was the first investigator to mention the change in temperature coefficient of inductance with frequency. He built a coil using metallized turns on a Calit form, obtaining a good molecular contact between metal and form. At low frequencies and up to 75 percent of the natural resonant frequency of the coil, good agree-

A basic need is for inductors with zero temperature coefficient of inductance. This original report presents an investigation into the causes of the inductor's temperature coefficient, an attempt to minimize the coefficient by using fused-quartz forms, methods of metallizing conductors on quartz, and equipment for measuring temperature coefficients.

Coefficient of Inductance *of Coils and Inductors*

ment was obtained between his equation and his results. At frequencies very low compared to the natural frequency of the coil, the coefficient of inductance is only slightly higher than the coefficient of linear expansion of the form. Later theory shows that this was caused by a fortuitous choice of a thin, flat conductor with large spacing between turns rather than by capacitance changes.

Janusz Groszkowski[3] attributed the excess in actual temperature coefficient of inductance over the theoretical to *eddy currents and skin effect* in the conductor of the coil itself, and made measurements using constantan (which has temperature coefficients of resistivity and linear expansion of 8 x 10^{-6} and 17 x 10^{-6} per deg. C.). Copper's coefficient of resistivity is 4200 x 10^{-6}. He built a copper coil and measured a temperature coefficient of inductance of 45 parts per million. When an equal number of turns of constantan were added, the coefficient was found to be 47 x 10^{-6}, but when the same number of turns of copper were added, the coefficient went up to 67 x 10^{-6}. He then made an identical coil of constantan and measured its inductance coefficient at 17 x 10^{-6} per degree centigrade, which is also its coefficient of expansion. When an equal number of copper turns were added, the coefficient increased to 28 x 10^{-6}, but when an equal number of constantan turns were added, the coefficient was found to be only 18 x 10^{-6}. From this, he concluded that eddy currents and skin effect have some bearing on the temperature coefficient of inductance because the constantan (which had almost no change in resistance with temperature) had inductance coefficients equal to its linear expansion coefficient, whereas the copper (which has a rapid change in resistance with temperature) had much higher inductance coefficients. Data was presented also to show that the number of turns had to be kept small and the conductors large in order to minimize the change in coefficient with frequency.

Internal Inductance

E. B. Moullin[4] divided the inductance of a coil into two parts—external and internal. The external inductance is the portion of the total inductance which is directly related to the magnetic field outside the wire. It is not a function of frequency and has a temperature coefficient equivalent to the coefficient of linear expansion of the metal. The internal inductance is related to the magnetic field inside the wire. This portion is a function of frequency and has a temperature coefficient which is some function of the temperature coefficient of resistivity of the wire. While this internal inductance is approximately 5 percent of the total for single-layer solenoids, it contributes greatly to the total temperature coefficient of inductance because it varies at a rate equal to the temperature coefficient of resistivity of the conductor metal. (Example: copper has a resistivity coeff. of 4200x10^{-6}/deg. C.)

The internal inductance can be decreased by using conductors of hollow tubing with thin walls, or by use of thin, flat strips. However, this is accompanied by an increase in resistance.

This is borne out by Thomas[5,6] who found that coils which were wound with flat strips having thin cross-sections could be made to have inductance temperature coefficients almost independent of frequency over a wide range; but beyond this range the coefficient rose rapidly with increasing frequency. He also found that the frequency at which the temperature coefficient of inductance started to rise could be increased by increasing the conductor spacing.

A. Bloch[7] reasoned that since the depth of penetration (and, therefore, the loss) varied according to the one-half power of the resistivity, the temperature coefficient of *internal inductance* for round conductors would be one-half the temperature coefficient of resistivity. He also showed that the temperature coefficient of inductance caused by resistance changes for the whole coil was:

$$\propto_L = \delta/2Q \qquad (2)$$

where δ = temperature coefficient of resistivity of metal in conductors, and Q = figure of merit for the coil.

In all the literature investigated, the non-compensated coil with the lowest coefficient of inductance was built by Thomas[6]. He used a fused-quartz form, 2.68-in. diameter by 3.75-in. long, on which he metallized, of copper, conductors of 19 turns which were 0.080-in. wide and 0.005-in. thick with 0.197-in. spacing between their centers. This coil had an inductance of 13.7 microhenries with a Q of 50 at 2 megacycles, and 95 at 6 megacycles. The temperature coefficient of inductance at 2 megacycles was 15 x 10^{-6} per degree centigrade and 52 x 10^{-6} at 6 megacycles. He indicated that the coefficient at 6 megacycles could be improved by decreasing the conductor

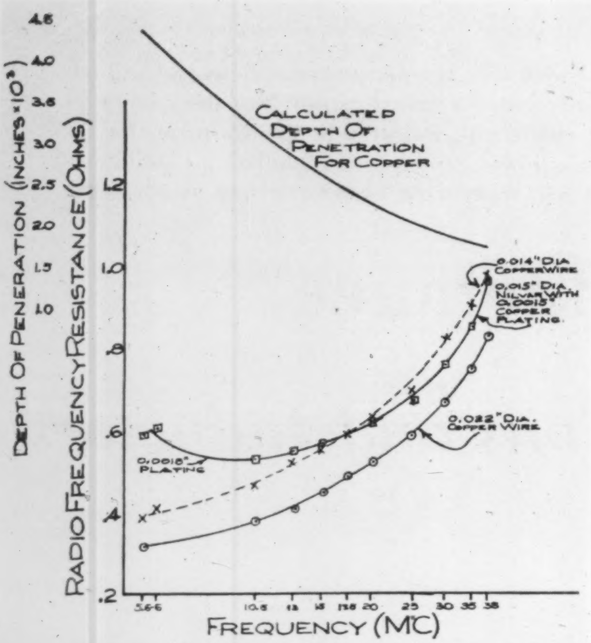


Fig. 1. Depth of penetration (in copper) and R-F resistance (of copper and copper-plated wires) as functions of frequency.

thickness, but this improvement would be at the expense of the Q, which is already low.

To summarize the investigation into the temperature coefficient of inductance of a coil, the coefficient is a function of these nine things: (1) frequency, (2) and (3) resistivity of and temperature coefficient of resistivity of the conductor, (4) and (5) temperature coefficient of linear expansion of both the conductor and forms, (6) conductor shape, (7) form shape, (8) winding pitch, and (9) number of turns. To minimize the temperature coefficient of inductance, the number of turns must be kept small and thin, wide conductors which are widely spaced and which have a low temperature coefficient of resistivity should be used. Unfortunately, all this tends toward a large coil with a low Q.

Experiments on Plated Wires

In order to check the internal-inductance theory some experiments were made using Nilvar wire, which has high resistivity but a coefficient of expansion of only 1 x 10^{-6}/deg. C. These were copper plated and their r-f resistance plotted vs. frequency in the region where depth of penetration was close to the plating thickness. Three coils were wound. One used 0.022-in.-diameter copper wire, the second had 0.014-in.-diameter copper wire, and the third had 0.015-in.-diameter Nilvar with a copper-plated surface 0.0015-in. thick. All wire sizes were considerably less than optimum for maximum Q. Curves showing radio-frequency resistance of these coils and depth of penetration of current into the copper conductors vs. frequency are shown in Fig. 1. The frequency range shown on these curves was used in order to reach the frequency at which the resistance of the plated wire became equal to the resistance of the equivalent copper wire.

The resistance values were calculated from inductance and Q readings; the depth of penetration was computed from Equation 3[8], which defines depth of penetration as the distance from the surface of a metal to that point at which the current has dropped to 2 percent of the value it had at the surface:

$$D = 0.636/(\mu\delta f)^{1/2} \qquad (3)$$

where D = depth of penetration in centimeters, μ = permeability, δ = specific conductivity (microhm-cm x $10^3)^{-1}$, f = frequency in cps, and δ for copper = 5.8 x 10^{-4} c.g.s. electromagnetic units at 20 deg. C.

At high frequencies, where penetration of current into the wire is equal to the thickness of plating, the radio-frequency resistance of the plated wire should be equal to the resistance of a copper wire of equal diameter. The wire with 0.0015-in. plating (total diameter 0.018-in.) had a resistance at 38 megacycles which was between the resistance values for the 0.014-in. and 0.022-in. copper wires. This was expected. As the frequency was lowered, however, the resistance curve for the plated wire did not drop as rapidly as the curves for the copper wires did. This showed that the resistance of the plated wire was held up by an ever increasing proportion of the current flowing in the high-resistance Nilvar. Finally, at low frequencies, so much of the current was flowing in the Nilvar that the resistance curve actually started to rise. This is predicted in reference 9.

This test showed that when thin copper plating was put on a wire which had a low temperature-expansion coefficient, in an effort to hold constant conductor dimensions, the loss was excessive. If the copper were thick enough to minimize losses, then current redistribution with temperature caused by resistance changes would be as great as for a copper wire of equal diameter, so no advantage would be obtained by using this composite wire.

The permeability of the Nilvar wire will increase the internal inductance. This greater internal inductance will change as the permeability changes with temperature. This adds another complex component to the over-all coefficient of inductance; for this reason and the one mentioned in the preceding paragraph, it was decided that the plated-wire idea was not practical.

Inductor Shielding

Any inductor is subject to instabilities caused by its surroundings. The best way to eliminate this is to put a shield around it, but care must be taken that the shield itself does not add to the inductor's coefficient of inductance.

The following calculations were made to determine the effect which the shield would have on the coil's inductance as it changed dimension with temperature. As installing the shield reduces the coil's inductance, any increase in shield diameter increases the inductance; as the shield expands with increasing temperature it adds a positive component to the coil's coefficient of inductance.

The data in Fig. 2 were calculated from the following equation[10], neglecting any end shields and with the assumption that the coil form does not change dimension:

$$L = L_0\,(D^3 - d^3)/D^3 \qquad (4)$$

where L is inductance of inductor with shield, L_0 is inductance of inductor without shield, D is diameter of shield, d is diameter of inductor, Δ T is Temperature change in deg. C., and $\propto$ = Coefficient of linear expansion of brass (18 ppm/ deg. C.)

From 4: $dL/dD = -3L_0d^3D^{-4}$

For one example, assume L_0 = 32 uh, d = 2.9 in., and D = 7 in.

$$dL/dD = 0.409 \text{ uh/cm}$$

$$\text{ppm/cm} = (\text{uh/cm})(10^6)/L_0 = 0.0128 \times 10^6$$

$$(\text{ppm/cm}) \times (\text{cm/deg. C}) = \text{ppm/deg. C}$$

$$\text{cm/deg. C} = D\propto\Delta T/\Delta T = 7(2.54)(18)(10^{-6})$$

$$= 320 \times 10^{-6}$$

Change in inductance is therefore:

$$\text{ppm/deg. C} = (0.0128 \times 10^6)(320 \times 10^{-6}) = 4.1$$

Since the ppm/deg. C is proportional to $\propto$:

$$\text{ppm/deg. C for Invar} = \propto_{\text{Invar}} / \propto_{\text{Brass}} \times 4.1$$

$$\text{ppm/deg. C for Invar} = 4.1(1)(10^{-6})/(18)(10^{-6}) = 0.23$$

Fig. 2 shows the component of temperature coefficient which a brass or Invar shield would introduce into an inductor. It shows that for close shields the effect can be large.

Metallization

Preliminary attempts at metallizing quartz were not successful. The test samples were fired in an air atmosphere in an electric furnace, and then electroplated. Both firing and plating were done according to directions furnished by the manufacturer of the silver paint being used. The original bond between quartz and fired silver was apparently good because the silver could be removed only with difficulty. However, after copper plating, the composite silver and copper film peeled off. It was found that the addition of extra oxygen to the furnace helped the material to stick.

Silver paint was put on a pyrex tube in the form of a helix. This was fired in the electric furnace with an air atmosphere while extra oxygen was fed to the inside of the firing chamber. The silver adhered well after firing and appeared metallic and shiny. After plating, the bond was still good and the material could not be peeled off.

Various masking techniques were tried in order to wind a helix on a coil form but were not successful because they tended to let conducting paint slip under the masked areas, or left ragged edges on the conductors.

Tests showed that translucent fused-quartz could not be used for these components. The quartz is translucent because of air trapped internally in the form of small bubbles. The trapped air expanded upon heating and dislodged large chips from the surface before the temperature necessary for bonding was reached.

Experiments were made to determine the strength of connections soldered to plated films on quartz. Solder connections of 0.01 square inch in area were made which could withstand a 15-pound pull in a direction parallel to the surface of the quartz.

Experiments were carried out with several paints; the best results were obtained with type #4760 conducting paint made by the Electrochemicals Department of the E. I. DuPont de Nemours Company in Wilmington, Delaware.

A 0.5-uh inductor was made on a fused quartz form using the techniques described below. It was 2.1-in. long and 0.4 inch in diameter, and had 13¼ turns which averaged 0.060-in. wide. It successfully withstood 20 cycles of being plunged from acetone at –25 deg. C into boiling water then back into the acetone.

For making the inductor, the procedure illustrated in Fig. 3 was used. The picture shows a helical conductor having 10 turns per inch being applied to a fused-quartz form of 1-9/32-in. diameter. The paint striper shown was mounted on the horizontal brass rod so that it was free to rotate. This freedom of motion allowed the end of the striper, which was pressed against the coil form, to move up and down to follow any slight irregularities in the quartz form, and to allow for any eccentricities which had been incurred in chucking. The equipment was set up so the striper wheel was at right angles to the axis of the coil form and touched its surface about 15 degrees in the direction of rotation beyond a vertical plane passed through the axis of the form. The lathe was set for a thread of 10 T.P.I. and a speed of 50 rpm, which had been found suitable for forms up to three inches in diameter.

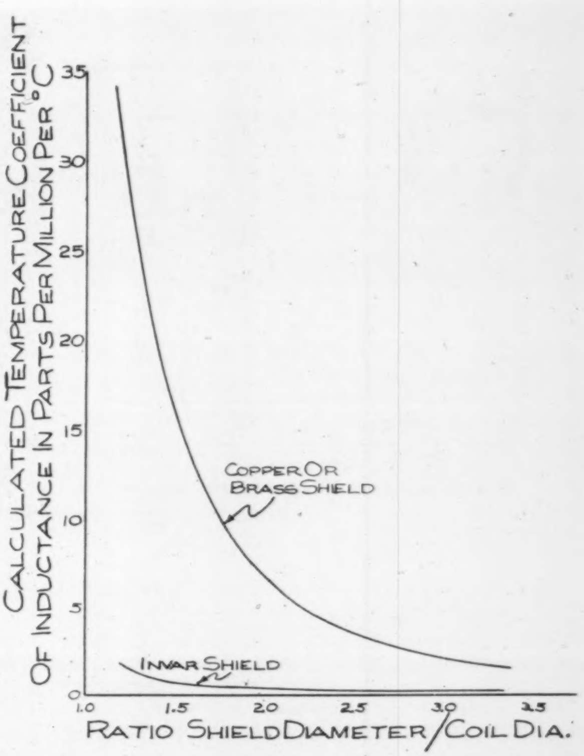


Fig. 2. Calculated temperature coefficient of inductance caused by shield around coil.

Before painting, the surface of the form had to be slightly roughened with a light sandblast to prevent the paint striper wheel from slipping. It was then cleaned with acetone.

The width of the conductor is determined mainly by the width of the striper wheel, and slightly by the speed of rotation of the lathe and consistency of the paint. A conductor width of 0.060 in. was used. An adequate consistency for the paint was found when thinned with toluene to the point where it dripped freely from a stirring rod.

It is easy to correct a mistake by cleaning the coil form with acetone and starting over. After a successful helix has been made, it is desirable to keep the lathe turning for five minutes to allow the paint to dry uniformly.

The firing schedule was critical and a certain procedure had to be followed exactly. The furnace which

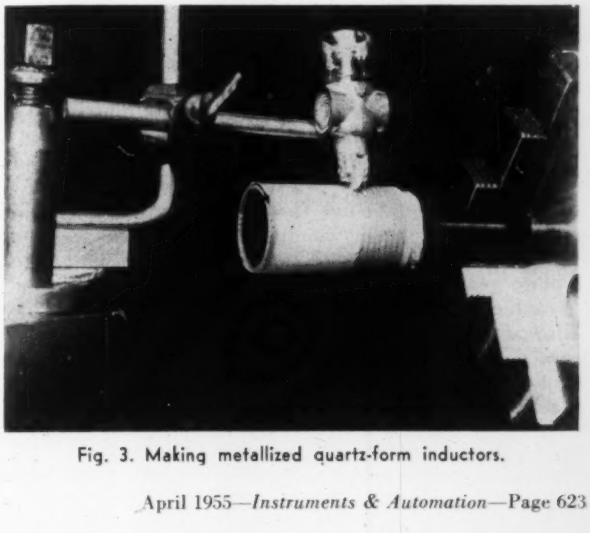


Fig. 3. Making metallized quartz-form inductors.

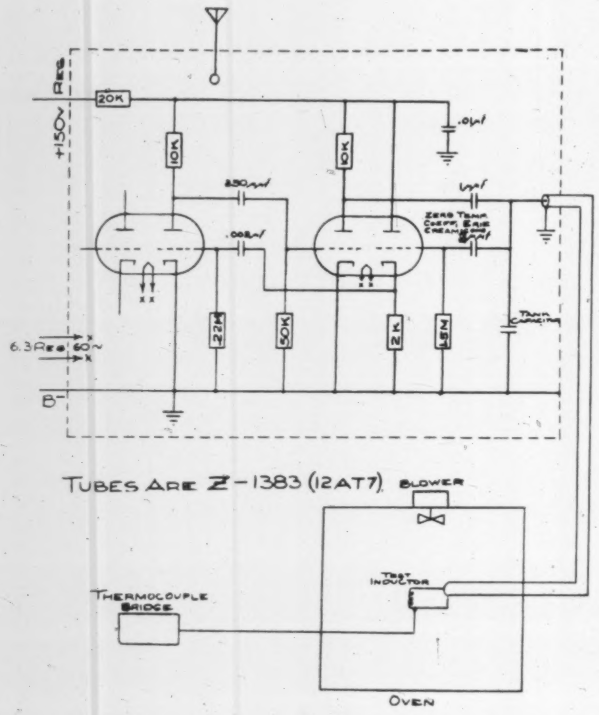


Fig. 4. Test oscillator used to measure test inductor.

fired the quartz was a Hoskins electric type. An external supply of oxygen was fed into the furnace to maintain a highly oxidizing atmosphere during the first part of the cycle.

For the inductors the schedule was as follows: (1) Extra oxygen was fed into the oven and then the quartz cylinder was placed inside. Oven and quartz were at room temperature. (2) The temperature was raised to 550 deg. C in one hour; that temperature was held for two hours while oxygen was fed into the furnace. (3) The extra oxygen was turned off and the temperature held at 550 deg. C for another two hours. (4) The power was turned off and both oven and quartz were allowed to cool slowly to 50 deg. before the quartz was removed.

The recommended bath used to copper plate these films consisted of 6½ ounces of sulphuric acid and 27 ounces of copper-sulphate crystals dissolved in one gallon of water. The films could not be burnished before plating. Stainless-steel electrodes were found essential. The plating must be done rapidly so as to keep the films in the solution as short a time as possible; however, it must not be so rapid that the copper becomes porous and high resistance.

Soldering to these films was done using low-melting-point solder and a flux made of one part of ammonium chloride dissolved in 100 parts of glycerine. The soldering had to be done rapidly and with the smallest amount of heat possible so that the quartz directly under the joint should not be damaged.

One reason for the low Q of the inductor was the difficulty of plating a thin conductor which is 20 feet long. The conductor for the 27.7-uh coil, before plating, had 8-ohms resistance to direct current so connections made to each end of the inductor in the plating bath would have allowed plating only on the ends. To plate copper in the center it was necessary to make many contacts along the conductor. When enough copper had been deposited to reach the Q of 133 at 5.5 Mc, the plating operation was stopped in order to minimize the possibility of damaging the bond between silver and quartz.

Test Equipment and Procedure

The inductor was tested as part of a tuned circuit of a highly stable oscillator. The change in frequency of the oscillator was measured as the temperature of the coil was varied. A precise method of measuring this frequency change consisted of beating the test oscillator with a signal from the primary frequency standards of the General Electric Company. These frequency standards had been in operation for many years and their accuracy was known to exceed that required by this work. The difference frequency was measured by means of an audio oscillator and oscilloscope.

A Franklin oscillator was satisfactory for this application. It was found that the stability of the Franklin oscillator could be increased by the addition of a cathode follower between the tuned circuit and the grid of one of the oscillator triodes (Fig. 4). The tubes used were a developmental type (Z-1383) which were built to possess a high degree of sturdiness and mechanical stability. A 7-in. diameter brass tube was used as a shield to minimize the effects of external disturbances.

To test the equipment, the frequency was set at 5 Mc with an ordinary tuned circuit, and the beat between it and the crystal frequency standards noted. When the plate voltage was raised from 225 to 325 volts, the beat frequency changed only 50 cycles per second. When the heater voltage was varied from 5 to 8 volts, the beat changed only 25 cps. This degree of stability was adequate.

The final technique for measuring coefficients of inductance used the tuned circuit shown in Fig. 4. The oscillator was beat against the crystal-controlled frequency standards, the beat frequency being measured by an oscilloscope and audio oscillator. As the temperature was varied, the beat frequency was measured and recorded. The change in the beat frequency was plotted vs. temperature. The slope (K_1) of this curve was calculated in ppm per deg. C. The coefficient of inductance of the test inductor was then:

$$\propto_L = -2K_1 \qquad (5)$$

Acknowledgments

This work was done while the author was a member of the General Engineering Laboratory of the General Electric Company. Special thanks should go to Mr. H. W. Kline and Mr. H. R. Meahl for their help and suggestions.

Bibliography

1. Moullin, E. B., "The Temperature Coefficient of Inductance with Special Reference to the Valve Oscillator," *IRE Proc.*, January 1935, pp. 65-84.
2. Thomas, H. A., "Stability of Inductance Coils for Radio Frequencies," *IEE Journal*, November 1935, Vol. 77, pp. 702-722.
3. Groszkowski, Janusz, "Temperature Coefficient of Inductance," *IRE Proc.*, April 1937, Vol. 25, pp. 448-464.
4. Moullin, E. B., "Temperature Coefficient of Inductance for Use in a Valve Generator," *IRE Proc.*, November 1938.
5. Thomas, H. A., 'Dependence on Frequency of the Temperature Coefficient of Coils," *IEE Journal*, January 1939, pp. 102-112.
6. Thomas, H. A., "Electrical Stability of Tubular Inductance Coils with Deposited Conductors," *IEE Journal*, May 1940, pp. 471-472.
7. Bloch, A., "Temperature Coefficient of Air-Cored Self-Inductances," *Wireless Engineer*, August 1944, pp. 359-367.
8. Hund, A. "Phenomena in High Frequency Systems," p. 334, McGraw-Hill, 1936.
9. Proctor, R. F., "High Frequency Resistance of Plated Conductors," *Wireless Engineer*, February 1943, pp. 56-65.
10. Pender and McIlwain, "Electrical Engineers Handbook," Wiley, 1941, p. 4-26.

INSTRUMENT-QUALITY AIR

"Instrument-quality" air is air suitable for a typical pneumatic control system. The term is defined and psychrometric factors are discussed. Aftercoolers, secondary aftercoolers, desiccant dehydrators, and combination systems are described for obtaining instrument-quality air.

PAUL HANKISON
Hankison Corporation

WHAT is meant by the term "Instrument Quality air"? As a general definition, we can say that "Instrument Quality" air is compressed air that: (1) is free of solid particles that could clog the smallest orifice in the system, (2) is free of oily sludge that could contaminate the instruments, and (3) has a dew point such that condensation of water vapor will not occur in any section of the system at any time or at any ambient temperature.

Another practical application of the term "Instrument Quality" air is the hope that the makers and users of pneumatic equipment will set standards by which the quality of compressed air can be evaluated.

In approaching the problem of eliminating moisture and contamination from compressed air, it is logical to find out why the air becomes contaminated in the first place. Atmospheric air always contains some moisture in vapor form. Every compressor, in addition to producing compressed air, also produces contamination of one sort or another. The lubricated compressor can inject water, oil vapor and oil, and carbon and tar products into the air system. These contaminants are caused by the lubricating oil being burned by friction of the pistons on the walls of the cylinders. A carbon-ring compressor can eliminate oil as a contaminant; however, carbon dust can become a contaminant. A water-seal-type compressor also eliminates the problem of oily contamination; however, the most serious contaminant—water—remains a problem.

Psychrometric Factors in Air

In order to show how water is generated in a compressed-air system, consider a cubic foot of air at atmospheric pressure and temperature, enclosed in a cylindrical vessel with a piston arranged so that pressure may be applied (Fig. 1). Assume a relative humidity before compression of 50 percent at 60 F. This means that the air contains one-half as much water vapor as it could contain at that temperature and pressure.

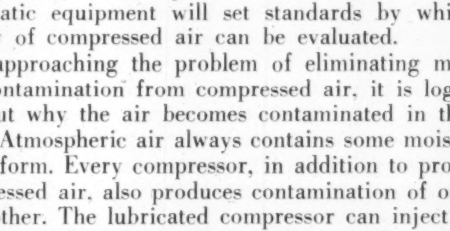


Fig. 1. Air containing contamination, before and after compression. Circles represent water and oil vapors; solid dots represent dust and dirt particles. Conditions before and after compression are given in Table I for both adiabatic (no heat lost) and isothermal (no temperature change) compressions.

As the piston is depressed, the energy applied increases both the pressure and the temperature of the gas. As the pressure is increased, the maximum amount of water vapor that can be contained in the gas is reduced; however, at the same time, the temperature increases and allows the air to accommodate a greater amount of water vapor. The net result is a gas with a high temperature and a low relative humidity, as shown in the table. However, this is true only in adiabatic compression—that is, a compression whereby all the generated heat is retained and the air remains at the high temperature. In a pneumatic control system, however, the air is never used at the temperature created during compression. Much heat is dissipated by radiation through the walls of the cylinder; more is lost through the air lines to the receiver, and the receiver itself radiates heat to the atmosphere. If an aftercooler is used, still greater temperature reduction is accomplished, and the air is often at 100 or 150 degrees as it leaves the air receiver.

The important aspect of the reduction in temperature is that as the temperature decreases, the ability of the air to hold water vapor decreases also, and the saturation point is reached while the air is still warm. As the air cools, its temperature reaches its dew point, saturation is exceeded, and the excess water vapor condenses into liquid. The final product is warm, saturated air in the receiver. This is shown in the table—the same air at 100 psig. and 60 deg. F. is saturated.

Table 1.—Temperature and Pressure Effects For Adiabatic and Isothermal Compression.

	Pressure (psig.)	*Temperature (deg.F.)*	*Relative Humidity*
A (original condition)	0	60	50%
B (after adiabatic compression)	100	485	38%
B (after isothermal compression)	100	60	100%

Presented at Conference on Instrumentation for the Iron & Steel Industry, Pittsburgh, March 25, 1954.

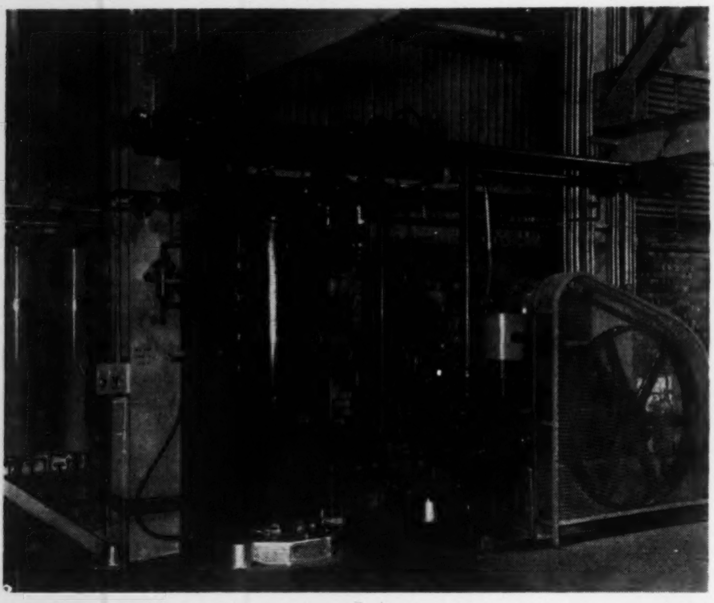


Fig. 2. Compressor installation in a boiler plant at a Pittsburgh steel mill. Compressor is at right. Large tank is the receiver. Horizontal pipes at top comprise a water-cooled aftercooler. Air from aftercooler then enters the two water-cooled "Condensifilters" shown at left for conversion to "instrument quality" air for use in the pneumatic controllers of the plant. Each "Condensifilter" is rated 100 scfm at 100 psig.

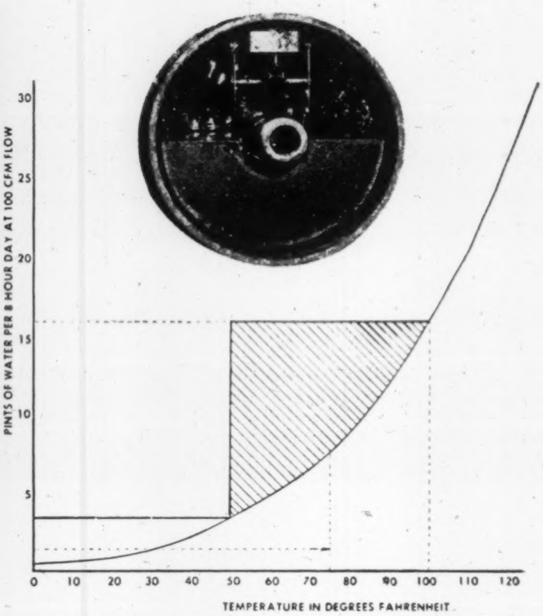


Fig. 4. Saturation curve shows pints of water carried in 8 hours by saturated air flowing at 100 cfm. Top illustration shows moisture condensed onto a device in a pneumatic system.

As the air leaves the receiver through the tubing it continues to lose heat; as the temperature is reduced, water is generated in the line. Although this water can be trapped out before the air is admitted to the control system, the air lines upstream from the trap may become corroded; this causes additional contamination that must be eliminated.

Dew Point

In order that only "Instrument Quality" air be distributed through the pneumatic system, *it is necessary that the dew point of the air be reduced below any temperature the air will encounter, in any part of the system, while the air is still at the higher pressure.* If this is accomplished, further condensation will be prevented and air lines will remain clean and dry.

Dew point can be defined as the compressed-air temperature below which water vapor is precipitated as a liquid. As air is cooled it reaches saturation at some temperature (the dew point) and water condenses out. If the air is cooled further, more liquid condenses out and the dew point falls to the lowest temperature to which the air is cooled. If the temperature is now raised, the dew point remains at the lowest temperature to which the air was cooled.

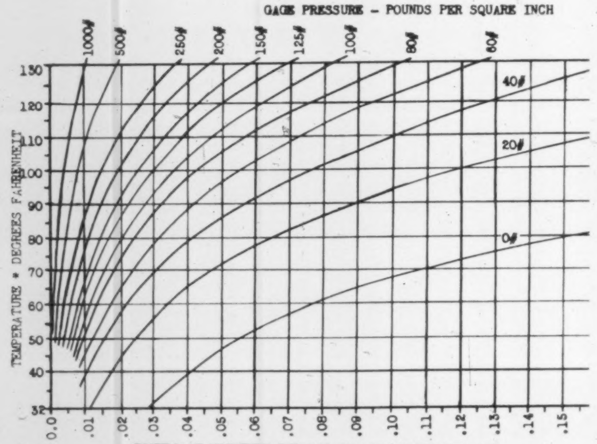


Fig. 3. Psychrometric chart shows pounds of moisture per 100 cu ft of saturated air at any given temperature and pressure.

A point where water often is generated is at the reducing valve. As the saturated air passes through the reducing valve, both temperature and pressure are reduced. The reduction in pressure reduces the dew point, but the reduction in temperature increases the dew point. Fig. 3 shows that at 500 psi and 100 F. saturated air can contain approximately 0.08 pound of water vapor per 1000 cubic feet. Now if we reduce the pressure to 100 psig at this same 100-F temperature, the air can contain 0.35 pound per 1000 cubic feet, more than four times as much as at 500 psi. If we follow the 100-psi saturation line to where it is saturated, with the same amount of water vapor we started with (0.08), we find the saturation temperature, or dew point, to be about 50 deg. F. However, during this expansion from 500 to 100 psig, the refrigeration effect will cool the air to below 50 F. Therefore, while we are reducing the dew point, we are, at the same time, also reducing the temperature; and saturation may momentarily be exceeded.

It is much easier to condense vapor than it is to evaporate the same weight of liquid because it is much easier to remove BTU from a vapor than it is to put BTU into the liquid. As a result, the condensed water remains as a liquid, and is carried on through the air lines with the air. Unless we reduce the dew point and relative humidity *before* pressure reduction, we will have trouble with water being formed at the reducing valve.

Use of Aftercooler

The conventional aftercooler has been used in an attempt to condense out a major portion of the water and thus reduce the dew point. Usually, however, the aftercooler is close to the compressor, and its inlet air temperature is high. Therefore, it seldom is able to reduce the air temperature to less than about 20 degrees above that of the cooling-water temperature. Hence the air

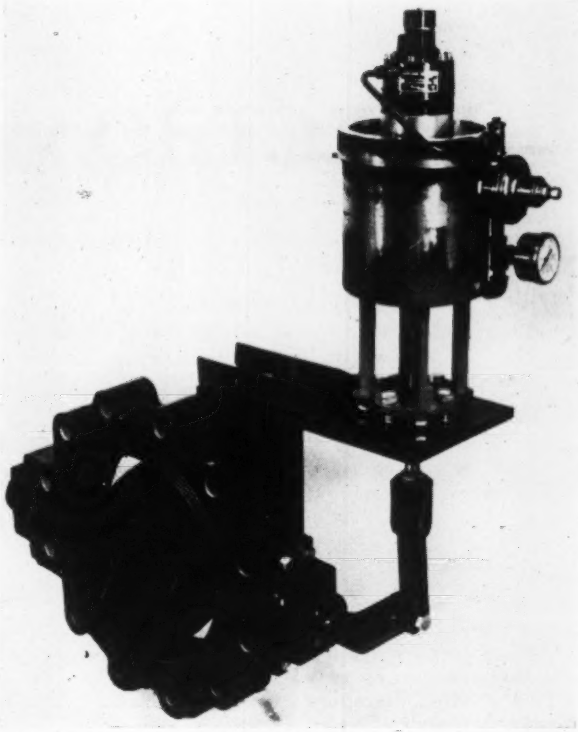


Fig. 5. Typical air-operated equipment that requires instrument-quality air for continuous service with low maintenance.

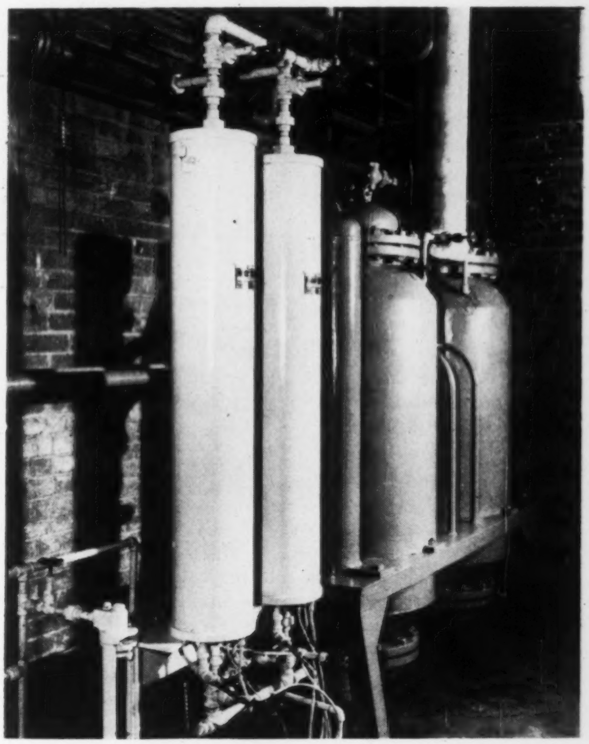


Fig. 6. This air supply at Sun Oil Co. boiler house, Marcus Hook, Pa., features two Condensifilters in combination with silica-gel dehydrators. Capacity is 100 cfm at 100 psig.

leaving the aftercooler is saturated at ambient temperature or above—but a dew point *lower* than ambient temperature is required.

When planning a compressed-air dehydrating and filtering system, the first thing to determine is the dew point necessary to prevent water from condensing in the lines. If the air lines are indoors, and the ambient temperature is always near 75 F, it is necessary to have a dew point of only 15 to 20 degrees below this temperature—that is, a dew point of about 60 degrees is satisfactory.

Use of Secondary Cooler

A conventional aftercooler alone usually can not produce even this relatively high dew point because of its high inlet air temperature. However, a secondary cooler, downstream of the aftercooler, can take advantage of the reduced temperature from the aftercooler outlet and thus can reduce the instrument air temperature far below ambient, producing a dew point of only a few degrees above the cooling-water temperature.

The efficiency of a cooler depends on its heat-transfer properties and on the temperature of the cooling water. If the outlet air temperature from the condenser is two or three degrees higher than the cooling water, the device will be satisfactory—if the cooling-water temperature is approximately 20 degrees less than ambient temperature. When the air has passed through the cooler, and has been reduced to about 20 degrees below room temperature, then allowed to warm to room temperature, a spread between temperature and dew point is effected; this spread of about 15 or 20 degrees usually is sufficient to prevent further condensation as the air progresses through the air lines to the instruments. Cooling should be done at the highest pressure possible because the later reduction in pressure will lower the dew point and relative humidity still further.

Desiccant-type Dehydrators

Although desiccant-type dehydrators are more expensive than mechanical or cooling types, a desiccant dehydrator often must be used to obtain "Instrument Quality" air. If cooling water is unavailable, or if the air lines are subjected to low outdoor temperatures, the desiccant dryer may be required.

Combination Systems

It may be advantageous and economic to use a combination of cooler and desiccant dehydrator. An efficient cooler will remove the major portion of moisture by condensation, and also condense out most of the oil. With a cooler ahead of a desiccant dehydrator, it is often possible to reduce the size of the dehydrator and prolong the life of the desiccant by removing the oily contamination.

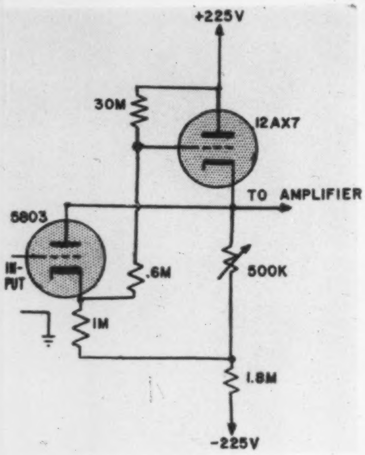
Production of "Instrument Quality" air can not be done by conventional mechanical separators and, therefore, is often considered expensive. On the other hand, the reduction of damage and maintenance for the instrument and control system makes the cost of proper filtering and dehydrating equipment a sound investment.

There are hundreds of devices sold for producing clean, dry air. The term "clean, dry air" is relative; before purchasing a filtering and dehydrating unit for instrument service, three questions should be asked:

1. Will this unit reduce the dew point of the air sufficient to prevent further condensation?
2. Will this unit remove all particles that could clog the smallest orifice in the system.
3. Will this unit remove oil, carbon, and tar products by the compressor?

If the answer to all three questions is "yes," then you can be sure the device will produce compressed air of "Instrument Quality."

ELECTROMETER FEATURES DRIVEN ANODE



An electrometer tube is designed and operated to have unusually high input impedance. By using a high vacuum, low operating potentials, low cathode-emission current, etc., grid currents are kept as low as 10^{-14} to 10^{-17} ampere.

To maintain low grid current the potential from plate-to-cathode (E_{pk}) must be less than about 10 volts; the potential from grid-to-cathode (E_{gk}) must not exceed —1 volt. Therefore, if the input signal is to exceed a fraction of a volt, it is necessary to drive the plate and the cathode by the signal voltage if the E_{pk} and E_{gk} are to be kept within the prescribed values—that is, the plate (as well as the cathode) must "follow" the grid.

This electrometer circuit (used in the "Model 210" of the supplier) uses both the electrometer tube (Victoreen Type 5803) and the driver tube (12AX7) as cathode followers. However, the cathode signal of the driver also drives the plate of the electrometer tube so that the E_{pk} of the latter never exceeds a few volts. (The 30 meg resistor is in a network that provides proper bias for the 5803.) The electrometer tube thus maintains its high input resistance even with grid excursions up to 80 volts. (A British instrument using same basic circuit permits ±500 volts to be applied to the electrometer grid.)

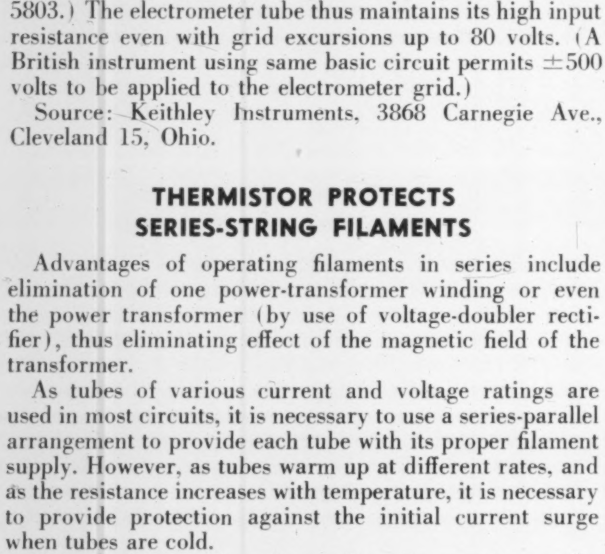
Source: Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.

THERMISTOR PROTECTS SERIES-STRING FILAMENTS

Advantages of operating filaments in series include elimination of one power-transformer winding or even the power transformer (by use of voltage-doubler rectifier), thus eliminating effect of the magnetic field of the transformer.

As tubes of various current and voltage ratings are used in most circuits, it is necessary to use a series-parallel arrangement to provide each tube with its proper filament supply. However, as tubes warm up at different rates, and as the resistance increases with temperature, it is necessary to provide protection against the initial current surge when tubes are cold.

This can be done by using a thermistor with negative temperature coefficient. As the thermistor resistance decreases with temperature, its effect cancels that of the tubes and protects against surges. Illustration shows use of a thermistor in an ac/dc radio-set string.



Source: R. A. Humphreys, *Sylvania News*, Jan., 1955. Also G. C. Church, *Service*, December, 1954.

ELECTRONIC

CHARLES F. KEZER

Potter Instrument Co.

and

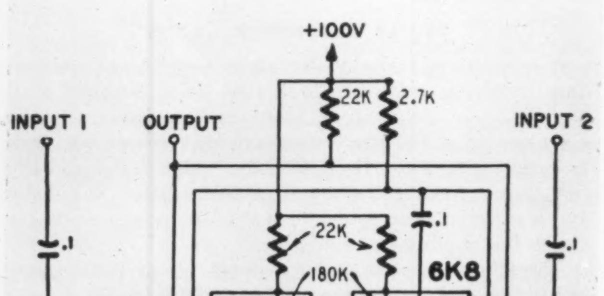
MILTON H. ARONSON

Instruments Publishing Co.

ELECTRONIC SWITCH

An electronic switch is a device that accepts two inputs and provides them both, alternately, at one output. By using the electronic switch, two signals can be traced on one oscilloscope screen for comparison.

The conventional electronic switch uses a free-running multivibrator that must be synchronized to the scope sweep, requiring adjustments and often producing a serrated trace. This electronic switch uses an Eccles-Jordan flip-flop (rather than a multivibrator). The flip-flop is synchronized by the 'scope sweep oscillator, and switch-



CIRCUITRY

The circuit is the heart of all electronics. Here are six more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

ing action takes place during the 'scope retrace time so that the trace is unbroken.

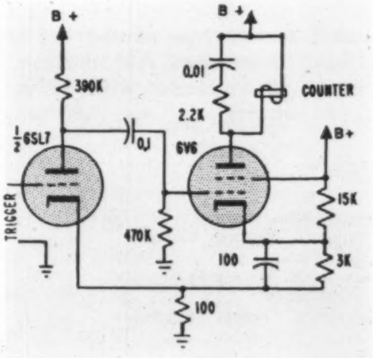
The flip-flop circuit uses the two triode sections of the two 6K8 tubes, which are triggered alternately by the trigger input from the 'scope sweep. Negative trigger inputs may be taken from the plate of the thyratron sweep oscillator (such as 884's) of the auxiliary oscilloscope (which accepts the output signal of the electronic switch).

Each triode section gates its associated pentode section, so that first input 1 and then input 2 is available at the output. The 50K balance potentiometer controls the d-c plate potential of pentode 1, and hence alters the spacing between the two traces on the auxiliary oscilloscope screen.

Source: Meir Weger in *Radio-Electronics*, Oct., 1954.

HARD-TUBE-DRIVEN COUNTER

Magnetic counters, or electromechanical registers, often are used for counting rates up to 10 per second. Usually a thyratron drive is used; however, this hard-tube trigger has the advantage of delivering better-shaped pulses to the counter, and of never failing to return to the nonconducting state after actuation.



The circuit is a one-shot multivibrator, with regenerative feedback from the 6V6 applied to the 6SL7 across the common 100-ohm cathode resistor; will operate counters rated at 110 v dc and 60 ma. Power tube 6V6 is normally cutoff by bias resistors that hold cathode at a positive potential. Negative input pulses of 0.5 volt or more will actuate the trigger, causing 6V6 to pass 100 ma for about 1/20 second. Duration of the current pulse, which is square-topped, is determined by the RC time-constant in grid circuit of the 6V6. The network in the 6V6 plate circuit absorbs the surge of voltage that is induced in the coil at the instant the 6V6 cuts off.

Input to trigger counter: 0.5 v or more, negative pulse.

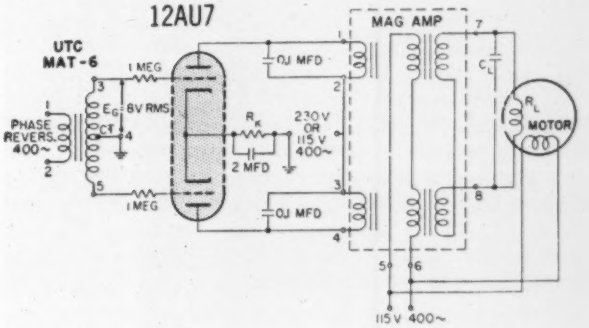
Counter: 110 v, 60 ma.

B supply: 360 v.

Source: L. Fleming in *Electronics*, September, 1954.

MAGNETIC AMPLIFIER DRIVES SERVOMOTOR

This 400-cycle servomotor is driven by a magnetic amplifier whose control windings are driven by a 12AU7 dual triode. The saturable reactor develops 115 v rms, phase reversible, across the control winding of the motor.



Full output is developed for 1 v rms input. DC inputs may be used by deleting the input transformer and applying push-pull signals of 13 v dc, grid to grid.

Power outputs up to 9 watts can be obtained, using commercially available magnetic amplifier units, at 115-v-rms supply voltage. Increasing supply voltage to 230 v rms doubles available output power.

Source Impedance: 10,000 ohms or less

Power Gain (magnetic structure): 40

Input: 1 v rms at 400 cps or 13 v dc, push-pull

Voltage output: up to 115 v rms, phase reversible, across motor control phase.

Power output: Depends on mag-amp unit used; up to 9 watts for 115 v rms supply.

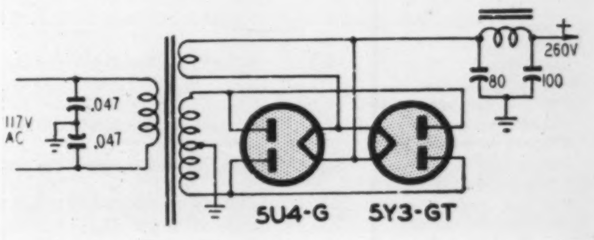
Max. null voltage: 3 v rms

Response time: 7.5 milliseconds.

Source: United Transformer Co., 150 Varick St., New York 13, N. Y.

5U4G-5Y3GT SUPPLY

Power supply (260-v) of RCA KCS72D TV chassis has unusual feature—a 5U4G and a 5Y3GT rectifier are connected in parallel as full-wave rectifiers. Lower impedance



of 5U4G tube causes 2/3 of current to be developed by it, only 1/3 is carried by 5Y3GT. Load is divided in proportion to ratings of the two types—5U4G is rated at 225 ma; 5Y3G at 125 ma. Use of split capacitors across line in technique used to reduce hum or to avoid an electrically "hot" chassis.

Source: *Radio-Electronics*, Nov., 1954.

Instrument Production Trends

RICHARD RIMBACH

Instruments Publishing Company

THE January 1954 issue of *Instruments and Automation* contained a report "The Instrument Industry—Today and Tomorrow." The data below are added to include devices which cover automation. The code classifications which have been included are: 3571—Computing and related machines; 3591—Valves and fittings; and 3616—Electrical control apparatus. The code classification 3586—Measuring and dispensing pumps, has been omitted in this report.

Dimensional gages and gage blocks, balancing machines, micrometers and verniers; plug, ring, snap and thread gages and other measuring tools, which are so important in automation are not included in this report as the Annual Survey of Manufactures includes these under Code 3543—Cutting tools, jigs, fixtures, etc.

Code Classifications and Definitions included in this Report

Code No. 3571—*Computing and related machines*, includes adding, calculating, tabulating, and bookkeeping machines; card-punching, sorting, and tabulating machines; and cash registers. It does not include typewriters and duplicating machines and devices.

Code No. 3576—*Scales and Balances*, includes weighing devices of all types, including those with automatic computer mechanisms and coin operated scales. Important products of this industry are industrial scales, commercial scales, household and person weighing scales, mailing and parcel post scales, railroad track and motor truck scales, as well as laboratory precision balances.

Code No. 3591—*Valves and fittings*, except plumbers' valves includes valves for controlling the flow of liquids or gases in pipes and mains, and for machinery including parts and fittings for such valves. It does not include plumbers' fittings (faucets, spigots, etc.).

Code No. 3613—*Electrical Measuring Instruments*, includes instruments for indicating, measuring and recording electrical quantities and characteristics and includes pocket, portable, panelboard and graphic recording instruments for measuring electricity, such as voltmeters, ammeters, watt-meters, watt-hourmeters, demand meters, and other meters and indicating instruments. This code also includes establishments primarily engaged in manufacturing meter transformers, and analyzers for testing the electrical characteristics of internal combustion engines, radio apparatus, etc.

Code No. 3616—*Electrical and control apparatus* includes switchgear, switchboard apparatus and industrial electrical controls. Important products of this industry include power switches, circuit breakers, contactors, and similar switchgear for general industrial application; switchboards and cubicles, control and metering panels; power fuse mountings, and similar switchboard apparatus and supplies; and industrial controls such as motor starters and controllers, electromagnetic brakes, and electronic inspection and gaging apparatus and positioning controls.

Code No. 3811—*Scientific Instruments*, includes laboratory, scientific and engineering instruments such as nautical, navigational, aeronautical, surveying, drafting, mathematical instruments, and instruments for laboratory work and scientific research.

Code No. 3821—*Mechanical Measuring Instruments* for indicating, recording, measuring, and controlling

Table 1. Annual Dollar Volume of Products Shipped by the Instrument and Automation Industry in 1953 compared with 1952 and 1947.

Product with Industry Code in Parenthesis	*Sales in Thousands of Dollars* 1953	1952	1947
Computing and related Machines (3571)	570,665	480,422	293,469
Scales and Balances (3576)	*	78,652	54,542
Valves & Fittings except plumbers (3591)	1,011,133	1,003,558	637,463
Electrical Measuring Instruments (3613)	390,772	299,006	153,380
Electrical Control Apparatus (3616)	1,220,910	1,088,188	628,283
Scientific Instruments (3811)	375,664	488,325	126,703
Mechanical Measuring Instruments (3821)	925,753	846,073	376,473
Optical Instruments & Lenses (3831)	150,230	122,695	36,081
Photographic Equipment (3861)	886,774	731,504	440,134
Watches and Clocks (3871)	413,287	361,504	341,199
TOTALS	5,945,188*	5,499,927	3,087,727

*Data on Scales and Balances withheld because the estimate did not meet publication standards.

Table 2. Average number of all Employees of the Instrument and Automation Industry in 1953 compared with 1952 and 1947.

Product with Industry Code in Parenthesis	1953	1952	1947
Computing and related Machines (3571)	56,789	53,256	46,375
Scales and Balances (3576)	*	6,683	6,526
Valves & Fittings except plumbers (3591)	78,954	80,068	80,075
Electrical Measuring Instruments (3613)	38,115	30,545	20,926
Electrical Control Apparatus (3616)	88,393	77,685	72,330
Scientific Instruments (3811)	31,394	41,494	20,384
Mechanical Measuring Instruments (3821)	78,876	75,426	53,237
Optical Instruments & Lenses (3831)	16,419	13,552	6,458
Photographic Equipment (3861)	60,165	54,839	50,911
Watches and Clocks (3871)	29,277	28,437	34,623
TOTALS	478,382*	461,985	391,845
All Employees	17,092,881	16,061,041	14,294,304

*Data on Scales and Balances withheld.

In January, 1954, The Instruments Publishing Company, after careful analysis of the Census of Manufactures, first reported the news that the instrument-industry 1953 volume exceeded $4 billion. More recent data now establishes the fact that the annual volume in 1953 exceeded $6 billion.

temperature, pressure, mechanical motion, rotation, flow, liquid level, humidity, density, acidity, alkalinity, and combustion; dial pressure gages; physical property testing apparatus such as hardness, tension, compression, torsion, ductility, and elasticity testing apparatus; and instruments for household and office use such as thermometers, barometers and rain gages.

Code No. 3831—*Optical Instruments and Lenses*, includes the products of establishments primarily engaged in grinding optical lenses and prisms, and in manufacturing microscopes, telescopes, field and opera glasses, and related optical instruments such as refractometers, spectrometers, spectroscopes, colorimeters, polariscopes, and optical measuring instruments. It does not include the manufacture of eyeglass lenses, frames or fittings.

Code No. 3861—*Photographic Equipment and Supplies*, includes still cameras, motion-picture cameras, projection apparatus, photocopy and microfilm machines; equipment such as plate and film holders, tripods, film reels, developing tanks and machines, enlargers, and motion-picture screens; and supplies such as sensitized film, paper, and plates; and prepared developers and fixers.

Code No. 3871—*Watches, Clocks and Parts*, except Watchcases, includes electric clocks, watches, mechanisms for clockwork-operated devices, and clock and watch parts. Establishments engaged in assembling clocks and watches from purchased movements and cases are included.

Growth of the Instrument Industry

This information on the growth of the Instrument Industry is taken from the recent issue of the 1953 Annual Survey of Manufactures and assembled by the Instruments Publishing Company.

Table 3. Productivity reported as Annual Dollar Volume of Products Shipped per Employee.

Product with Industry Code in Parenthesis		1953	1952	1947
Computing and related Machines	(3571)	10,150	9,050	6,320
Scales and Balances	(3576)	*	11,840	8,350
Valves & Fittings except plumbers	(3591)	12,840	12,450	7,880
Electrical Measuring Instruments	(3613)	10,220	9,800	7,340
Electrical Control Apparatus	(3616)	13,810	14,000	8,680
Scientific Instruments	(3811)	11,950	11,800	6,200
Mechanical Measuring Instruments	(3821)	11,720	11,200	7,930
Optical Instruments & Lenses	(3831)	9,260	9,020	5,570
Photographic Equipment	(3861)	14,710	13,340	8,640
Watches and Clocks	(3871)	14,100	12,700	9,850

*Data on Scales and Balances withheld because the estimate did not meet publication standards.

Test Your I. Q. (Instrument Quotient)

See Page 656 for Answers

All Questions are based on editorial matter in this issue.

Question 1

The analog computer can be valuable in process-control analyses because
(a) it permits rapid analysis of complex systems
(b) it can simulate nonlinearities such as dead time
(c) it requires only empirical transfer-function-type descriptions of the process unit
(d) all the above is true

Question 2

The operational amplifier is a basic component of an analog computer. Which of the following statements about the amplifier is true?
(a) One to 40 or more can be required for a given problem
(b) It is a high-gain a-c amplifier with a gain of millions
(c) It is used for summing only
(d) It is used for integrating only

Question 3

Feedback is used with the operational amplifier to effect various operations. Which of the following statements about the circuit is true?
(a) The input element is always a 1-meg resistor
(b) The feedback element is a resistor when integration is desired
(c) Amplifier input, or virtual ground, always remains near zero potential
(d) All the above is true

Question 4

For multiplication of varying qualities, the analog computer can use a servomultiplier. Which of the following statements about the servomultiplier is true?
(a) It contains a servo motor and several potentiometers
(b) One input controls the motor, which moves the sliders of all the potentiometers
(c) It is used to obtain x^2
(d) All the above is true

Question 5

A thermistor is often put in series with filaments of tubes in order to
(a) protect against excessive line voltage
(b) protect against initial current surge
(c) indicate an open circuit
(d) effect a time delay for a relay

Question 6

Recent data from the Census of Manufactures indicates that the annual volume of instrument and automation equipment in 1953 was approximately
(a) $200 million
(b) $600 million
(c) $4 billion
(d) $6 billion

Question 7

Dew point of compressed air is the
(a) temperature at which moisture begins to condense
(b) pressure at outlet of compressor
(c) temperature at outlet of compressor
(d) water content of saturated air

Question 8

The so-called "internal inductance" of a coil refers to the
(a) magnetic field within the coil itself
(b) magnetic field within the wires of the coil
(c) magnetic field coupling two adjacent coils
(d) all the above

Question 9

A process consists of three tanks in series. Liquid flows from tank 1 to tank 2 to tank 3, through valves between the tanks. Which of the following statements about the equation giving the level of tank 3 in terms of the process constants is true?
(a) The equation is a second-order differential equation
(b) The coefficients of each term are constants of the R-C type
(c) Each coefficient appears independently of the others so that change in one R-C constant does not affect the other coefficients
(d) All the above is true

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SPECIFICATIONS

Standard Types—ZQA (quick-acting), ZSO (slow-operating), ZSR (slow-releasing), ZSA (slow-acting), and ZFA (for a-c operation).

Operating Voltage—Series ZQA and ZSA, up to 135 volts, dc; Series ZSO and ZSR, up to 115 volts, dc; Series ZFA, up to 115 volts, ac.

Contact Spring Capacity—Series ZQA, ZFA, and ZSO, 13 springs; Series ZSA and ZSR, 6 springs.

Contacts—Normally single. Load-carrying capacity, 150 watts.

Dimensions—Overall length, 2½"; height, 1½" to 2¾"; width, 1¼" for single pile-ups, 1½" for double pile-ups.

Net weight—4-6 oz.

Can be plug-mounted—ask for Circular 1804

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Journal of the SCMA . . .

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Maintenance of

Gas Pressure Regulators

The severity of application affects the maintenance required of gas-pressure regulators. Programs and details are given for both domestic and industrial regulators. Friction and velocity effects are discussed in detail.

LOUIS J. DELANEY
American Meter Company, Inc.

PURPOSE of this article is to establish minimum frequencies for the field inspection and maintenance of domestic, industrial, district, and transmission regulators. Such periodic inspections are to be made to determine that the component parts of the regulators are functioning correctly and not excessively worn. Where malfunctioning or excessive wear is found, the regulator is to be repaired or replaced.

The domestic (house type) regulator generally is checked by the customer serviceman at the time of a meter change or of a customer complaint. The maximum policy is for the serviceman to check (by means of a water-column U-gage) the outlet pressure of the regulator, and make necessary adjustments to bring the pressure within allowable tolerances. If circumstances permit and if economically feasible, some gas companies have the serviceman check the regulator for lock-up; if the lock-up is too high (2-inch w.c. above set pressure) the serviceman either can change the valve-seat disc and the orifice, or he can replace the regulator with a new one. As a last inspection step the serviceman may soap-test the regulator vent for possibility of a leaking diaphragm.

A very important factor is the dust or dirt (such as sand, pipe scale, or thread cuttings) in the line to which the regulator is installed. A new regulator is carefully ground-in or "seated" and sent to the field. It may open only once, and then close on a small piece of hard substance which will hold it just slightly off its seats until the erosion of the gas passing over its seats causes the regulator to no longer shut tight—even after the particle of foreign matter has been dislodged. It is, therefore, of extreme importance to blow out thoroughly all lines connected with the regulators before putting the regulator into service. On most regulators little trouble is experienced if the dust is perfectly dry because the dust will pass by the seats without clinging to them. However, if the dust is damp due to condensates or odorant oil, it will stick to the seats. On some house-type regulators that have been removed from service the dust was found piled up in a cone on the seat, restricting the flow of gas.

May Meeting: *Thursday, the 19th, Rio Hondo Country Club, Downey, Calif.*
Feature: *Carl F. Keyes, Southern California Gas Company, will present a talk on "Control of The Flow of Natural Gas to The Los Angeles Area."*

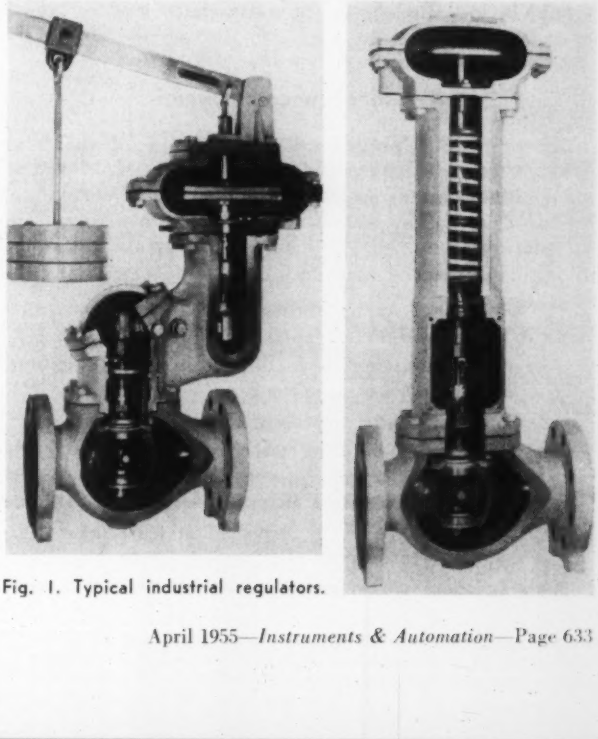


Fig. 1. Typical industrial regulators.

Fig. 2. Repairing regulators.

Industrial Regulators

Industrial regulators, which include from $1\frac{1}{2}$-inch single-valve types to 12-inch balanced-valve types, are maintained and inspected in a manner similar to domestic installations. Most industrial regulators incorporate a recording pressure chart.

Any time an industrial customer shuts the gas supply off completely, it is advisable to check the regulator for lock-up, at frequent intervals.

An industrial-regulator maintenance program depends on the pressure reduction, load conditions, and the past experience. The frequency at which an industrial regulator is taken out of service and completely overhauled would be indicated by the pressure charts and by experience.

A Maintenance Program

The following program is that of one of the large western gas companies for maintenance and inspection of regulators on transmission lines (1) at delivery points to the distribution system, (2) from transmission lines or stations, and (3) at compressor plants, including monitoring lines or stations.

A. Regulators are to be inspected at least once each year if failure to function correctly could result in:

(1) Over-pressuring a facility above its maximum allowable working pressure.

(2) Interruption of service to a town or district.

(3) Any other condition which, in the judgment of the supervisor, would present a hazard to life or property, or cause a serious interruption of service.

B. Regulators are to be inspected at least once every three years if failure to function correctly would result in:

(1) Temporary discontinuation of a compressor station's operation, such as the shutting off the stations fuel supply, so long as it would not cause an outage, or create a hazardous condition.

(2) Affecting the supply to an area or district so that a serious dispatching or operating problem would be presented, but which would not cause an outage or create a hazardous condition.

(3) Any other situation which would present a serious operating problem without creating a hazardous condition or serious interruption of service.

C. All other regulators, including regulators in stand-by 'no-flow' service, are to be inspected as required by the supervisor. Stand-by regulators, however, are to be placed in service, or otherwise checked for proper operation, not less than once every three years.

Inspection normally is meant to consist of dismantlement of the regulator and inspection of the valves, guides, posts, bushings, couplings, seats, valve stems, pins, diaphragm, head, spring, spring stem, and any other moving parts. Dismantlement is not required if complete inspection can be accomplished by other means, such as use of inspection openings. The diaphragm assembly need not be dismantled each time the regulator is inspected if the frequency between inspections is two years or less, and if its operation can be otherwise checked during the interim inspections. In such cases, however, the diaphragm assembly is to be dismantled and inspected at least once every four years.

Friction and High-velocity Effects

In addition to dust, there are two other factors that must be considered when maintaining regulators—friction and high velocity.

Friction is the greatest enemy of all regulators. It is the element that can never be balanced out. It retards the motion of the valve in opening, as well as closing. Much time and effort have been and always will be devoted to the elimination of this destroying force.

Ball bearings which roll in vertical races have been inserted to diminish the resistance to the stem connecting the diaphragm and the valve. Joints and bearing surfaces have been removed from the design of regulators wherever engineering ingenuity has been able to do so. Where stems pass through stuffing boxes they have been reduced in size and made of stainless steel to minimize friction. There is, of course, less friction around small stems than around larger ones. The use of "O" rings instead of stuffing boxes has been a big factor in eliminating friction and reducing service calls, not to mention their good sealing qualities.

High velocities across valves, even when the gas is clean, can cause erosion. Therefore, special valve seats of heat-treated tool steel, or a new composition of polyethylene, may be used. Regulators using this new material in exacting pressure-reducing service reducing (from 1000 to 30 psi in one step) showed no appreciable wear for nearly eleven months.

Pressure Reduction

The question "How much pressure reduction should be allowed through one regulator"? was answered very nicely by Mr. C. S. Beard in the following manner: "The pressure cut is unlimited, assuming (1) that the parts of the reducing valve are designed to withstand the velocities and unbalance, (2) that the actuating means has the power to position the valve, and (3) that conditions are not sympathetic to 'freezing'."

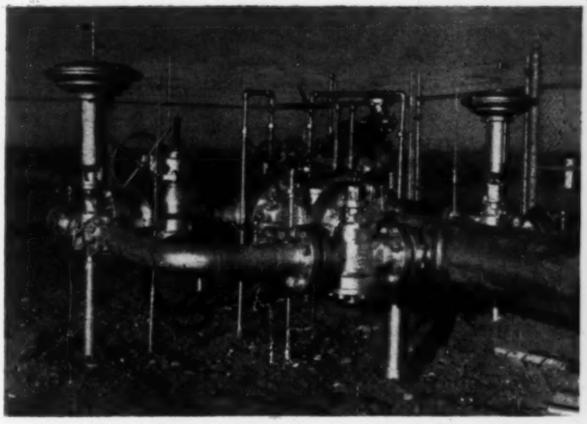


Fig. 3. Transmission installation at Millar Station, Pacific Gas & Electric Co., San Joaquin Valley.

It is difficult to set down a positive set of standards that are applicable to every regulator station and every gas company. It is the responsibility of each operator to determine minimum maintenance frequencies for the regulators within their jurisdiction, and to establish more frequent inspections where necessary.

Events . . .

INSTRUMENTS and AUTOMATION

April 18

Midwestern Simulation Council meeting at Bendix Research Laboratories, Detroit City Airport, Detroit, Mich.

April 24-28

37th Annual Meeting of the Scientific Apparatus Makers Association will be held at The Greenbrier, White Sulphur Springs, W. Va.

April 25-26

First National Conference of Instruments and Regulators Division of A.S.M.E. will be held at University of Michigan, Ann Arbor, Mich. For information write J. A. Hrones, Massachusetts Institute of Technology, Cambridge 39, Mass.

April 27-29

Society for Experimental Stress Analysis 1955 Spring Meeting will be held at Hotel Statler, Los Angeles, Calif. For information write W. M. Murray, P. O. Box 168, Central Square Station, Cambridge 39, Mass.

May 2-5

Annual Research Equipment Exhibit and Symposium in Instrument Techniques and Applications, National Institutes of Health, Bethesda, Maryland. For information, write to the Supply Management Branch of NIH.

May 12

Western Simulation Council Meeting. Place: To be announced.

May 12-13

Annual Meeting of the Society for Applied Spectroscopy, Hotel New York, New York City. For information write Garton L. Crumvine, North American Smelting Co., Marine Terminal, Wilmington, Del.

May 14-22

Chemical Engineering and Equipment Exhibition at Frankfort, Germany. For information write Dechema, Rheingan-Allee 25, Frankfort/M, Germany.

May 16-20

40th National Conference on Weights and Measures, sponsored by the NBS, will be held at the Shoreham Hotel, Washington, D.C. For information write W. S. Bussey, NBS, Washington 25, D. C.

May 18-20

National Telemetering Conference sponsored by the IRE, AIEE, IAS and the ISA, held at the Hotel Morrison, Chicago. For information write Raymond C. Mayer & Associates, 36 West 46th St., New York 36, N. Y.

May 23-25

Ninth Annual Convention of American Society for Quality Control, Hotel Statler, New York City. For information write Ellis R. Ott, Rutgers University, New Brunswick, New Jersey.

May 23-27

Third Annual Conference on Mass Spectrometry, sponsored by the ASTM Committee E-14 will be held at the Mark Hopkins Hotel, San Francisco, Calif. For information write J. G. Hutton, General Electric Co., 1 River Rd., Schenectady, N. Y.

June 6-10

Third Human Engineering Institute will be held at Dunlap & Associates, Inc., 429 Atlantic St., Stamford, Conn. For information contact M. A. Tolcott, c/o Dunlap & Associates.

June 7-9

Committee on Vacuum Techniques, Inc., will hold their Second Symposium on Vacuum Technology at Mellon Institute, Pittsburgh 13, Penna. For information write Rudy Koehler, Committee on Vacuum Techniques, Inc., Box 1282, Boston 9, Mass.

June 9-10

Conference on Carbon will be held at University of Buffalo, Buffalo, N. Y. For information write Carbon Conference, Department of Physics, University of Buffalo, Buffalo, New York.

June 14-16

First Magnetics Conference and Exhibit sponsored by the Basic Science Committee of the American Institute of Electrical Engineers in cooperation with the American Physical Society and the American Institute of Mining and Metallurgical Engineers, William Penn Hotel, Pittsburgh, Pa. For information write A. C. Beiler, C/O Westinghouse Electric Corp., 2-F Materials Engineering Department, East Pittsburgh, Pa.

November 14-17

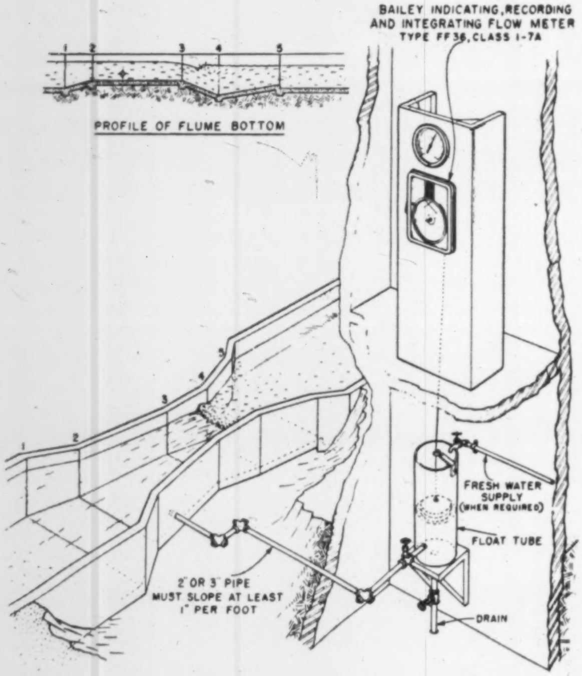
Second International Automation Exposition will be held at Chicago's Navy Pier. For information write The Second International Automation Exposition, 845 Ridge Ave., Pittsburgh 12, Penna.

Briefs...

For this literature use postage-free order card on page 667

Open-channel Flowmeters

The universal application and complete flexibility of Bailey Open Channel Meters is demonstrated by the fact that they may be used for or with practically: any fluid (sewage, sludge), any open-channel device (Venturi flumes, weirs, or nozzle flumes), any mounting, any range, any register, any control problem (ratio, chemical feed), any telemetering application, any operator. (*From new* 12-*page Bulletin M22-5, Bailey Meter Co.,* 1050 *Ivanhoe Rd., Cleveland* 10, *Ohio*)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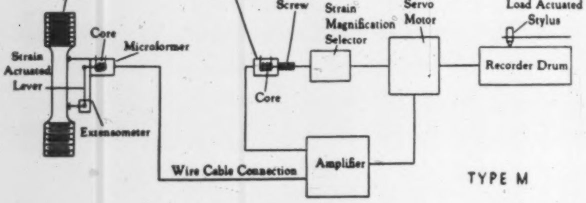
1
2
3
4
5
PROFILE OF FLUME BOTTOM
FRESH WATER SUPPLY (WHEN REQUIRED)
FLOAT TUBE
2" OR 3" PIPE MUST SLOPE AT LEAST 1" PER FOOT
DRAIN

For more literature circle **501** on inquiry card.

Microformer Stress-strain Recorder

The Microformer type recorder takes its name from the miniature transformer (Microformer) which is its key feature. The operator of the Microformer type (MODEL M) recorder is illustrated.

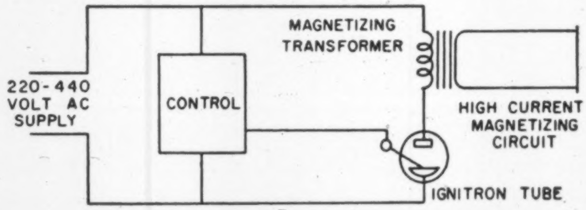

Specimen
Core
Microformer
Strain Actuated Lever
Extensometer
Microformer
Micrometer Screw
Core
Strain Magnification Selector
Reversible Servo Motor
Load Actuated Stylus
Recorder Drum
Amplifier
Wire Cable Connection
TYPE M

Increasing deformation of the specimen moves a strain-actuated lever in the strain follower. Movement of this lever displaces the movable core of the Microformer, and the movement of this core induces a change in the output of the Microformer, upsetting the balance between it and a similar Microformer in the recorder. This unbalanced signal is amplified and drives the servo motor. The servo motor in turn rotates the recorder drum, and at the same time moves the core of the recorder Microformer to a position in which its output again balances that of the Microformer in the strain follower. As the specimen continues to deform under load, the cycle is repeated. (*From new 28-page Bulletin* 4215, *Baldwin-Lima-Hamilton Corp., Phila.* 42, *Pa.*)

For more literature circle **502** on inquiry card.

How To Magnetize Magnets

Many permanent magnets and permanent magnet assemblies, because of their size and shape or pole arrangement, cannot be magnetized by conventional methods employing solenoids and electromagnets. This has led to the development of impulse magnetizers which deliver large pulses of unidirectional current to a single-turn or multi-turn magnetizing loop. This makes possible the magnetization of magnets which form an almost completely closed loop and those in which the reluctance of the air gap is less than the reluctance of the magnetic material. (*From* 12-*page Vol.* 3, *No.* 1 *issue of "Applied Magnetics," Indiana Steel Products Co., Valparaiso, Ind.*)


220-440 VOLT AC SUPPLY
CONTROL
MAGNETIZING TRANSFORMER
HIGH CURRENT MAGNETIZING CIRCUIT
IGNITRON TUBE

HALF CYCLE MAGNETIZER

For more literature circle **503** on inquiry card.

Titanium

Titanium was discovered in 1791. But it was not until recently, through the combined efforts of the Bureau of Mines and industry, that it was made available to the metalworking trades.

Titanium is a silvery gray metal possessing an unusual combination of properties which make it a most promising material for a host of new applications.

Outstanding among its advantages are the characteristics of light weight and high strength. Titanium is classified as a light metal—it is only 56% as heavy yet is 90% as strong as alloy steel; and is only 60% heavier than aluminum. The ratio of fatigue limit to tensile range is between .55 and .85 for unalloyed titanium, compared with .5 and .3 for steel and light alloys, respectively.

Other advantages are corrosion resistance, good ductility, formability, and heat resistance. Titanium is also nonmagnetic. (*From new 8-page Bulletin* 43, *covering fabrication and applications of titanium, Superior Tube Co.,* 1566 *Germantown Pike, Norristown, Pa.*)

For more literature circle **504** on inquiry card.

Cylinder Conomotors

The Cylinder Conometer is a pneumatically positioned power operator developed by Conoflow Corporation for powering any control element used in the "control loop" of automatic operations.

The output signal can be either electronic or pneumatic,

New ATLANTIC *Reformer at Atreco Refinery features Swartwout Autronic Control*

Atlantic's Catforming means high octanes . . . high yields . . . low cost . . . proved performance. And for its new Catformer at the Atreco Refinery, Atlantic specified Swartwout's Autronic Control System—the revolutionary step forward in sensitive, precise process control.

It senses . . . controls . . . indicates and records pressures, temperatures and flow. And the Autronic System does it electronically without boosters, slide wires, motors or troublesome air lines.

Call in our engineering representative to explain how the Swartwout Autronic Control System can bring new accuracy and speed to *your* process instrumentation. Or write today for literature on the *proven* Swartwout Autronic Control System.

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Swartwout *Autronic* CONTROL SYSTEM

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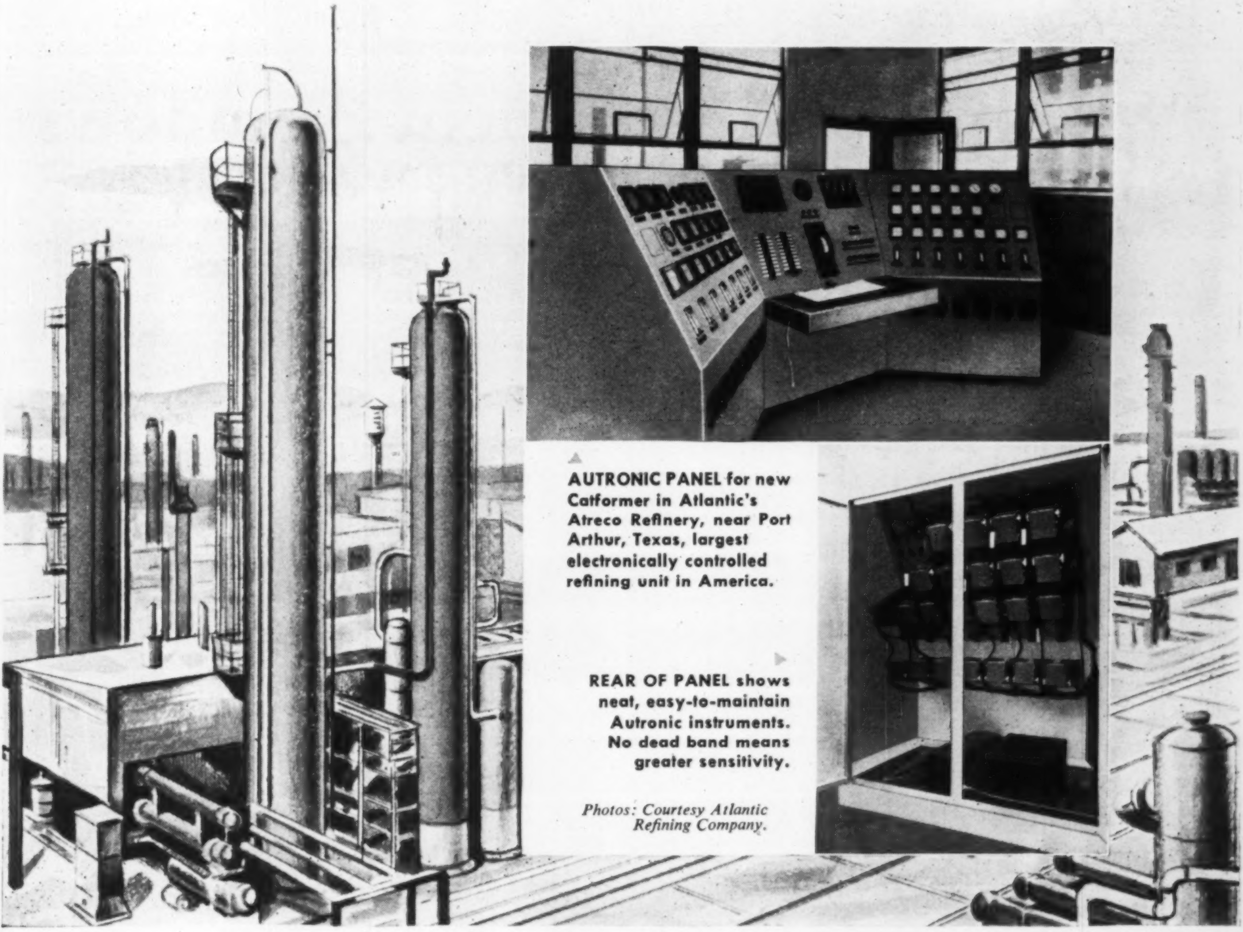
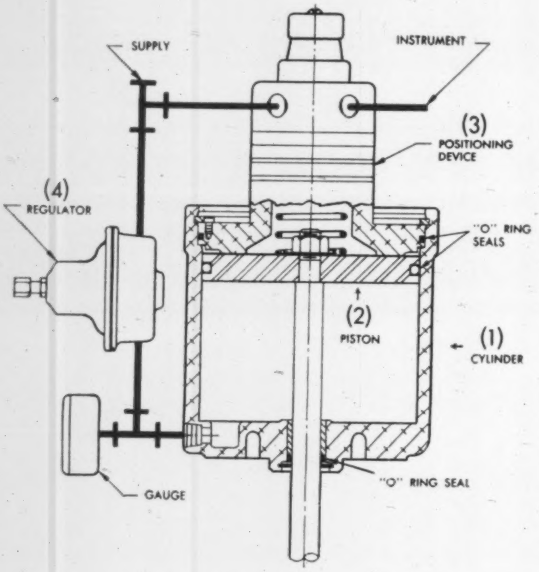


AUTRONIC PANEL for new Catformer in Atlantic's Atreco Refinery, near Port Arthur, Texas, largest electronically controlled refining unit in America.

REAR OF PANEL shows neat, easy-to-maintain Autronic instruments. No dead band means greater sensitivity.

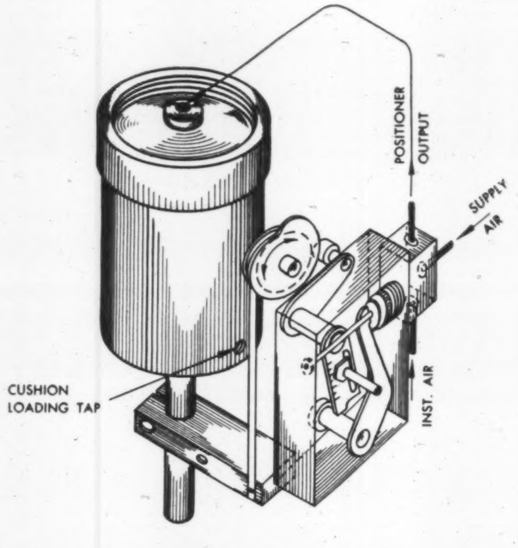
Photos: Courtesy Atlantic Refining Company.

For more information circle **97** on inquiry card.



depending on the type of instrument used. In pneumatic instruments, the conventional signal range is 3 to 15 psi and within this range, the instrument is generally capable of modulating the signal in increments of as small as one part in one thousand.

The Cylinder Conomoter consists of (1) a specially designed cylinder, (2) a piston with "O" ring seal, (3) an integral high-capacity positioning device and (4) a "cushion" loading regulator.



External positioner type Cylinder Conomotor

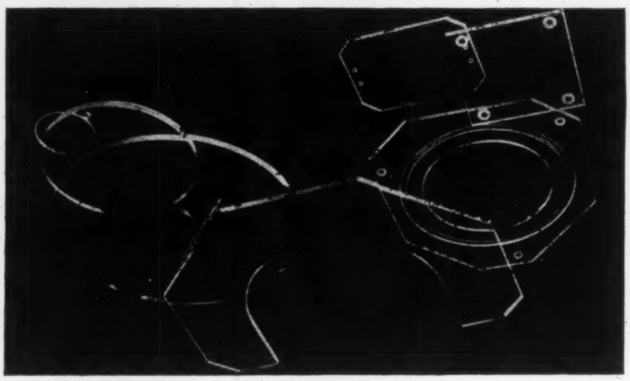
Cylinder Conomoters are available in a variety of diameters and areas, travels and mounting arrangements, ranging from 2¼" bore to 10" bore with travels up to 10" in the larger sizes. When travels are greater than 4", or when "characterization" is required, a cam-and-lever type of external positioning device is employed. Cylinder Conomotors can develop thrusts as high as 5000 lbs., yet are capable of holding these thrust loads to within .002" of stem travel when positioned from automatic control instruments. (*From new 12-page Bulletin B-50, Conoflow Corp., 2100 Arch St., Phila. 3, Penna.*)

For more literature circle **505** on inquiry card.

IDEAL for Instrument Windows
AND OTHER INDUSTRIAL APPLICATIONS

CR-39

is an optically clear, rigid, thermally-set plastic comparable to polished plate glass in lustre, smoothness and resistance to chemicals, wear, abrasion, weathering—outstanding for impact resistance!



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Get all the facts on CR-39 and our various other products. They can add wear, usefulness and value to your products.

Write Us Today!

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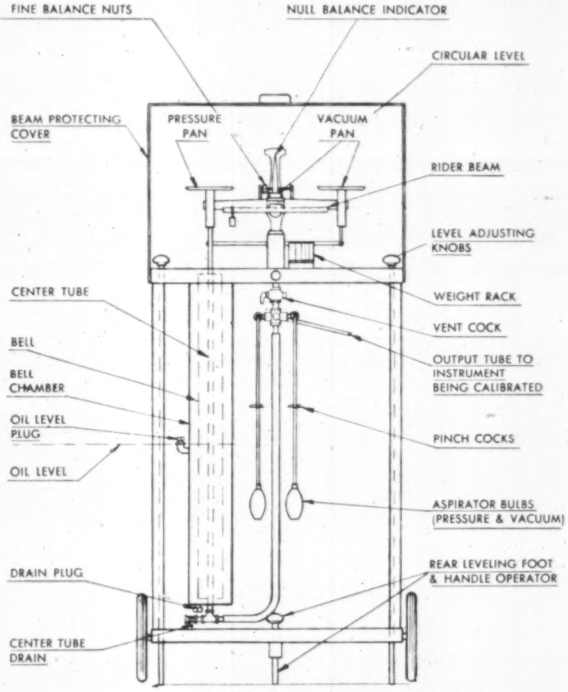
DEPT. A, 123 NEWMAN ST., HACKENSACK, N. J.

For more information circle **98** on inquiry card.

Low-Pressure Calibrator

The Republic Low Pressure Calibrator was developed . . . to accurately calibrate low-pressure instruments such as diaphragm gages and differential-pressure transmitters . . . It has proved to be more accurate and easier to use than water-column manometers.

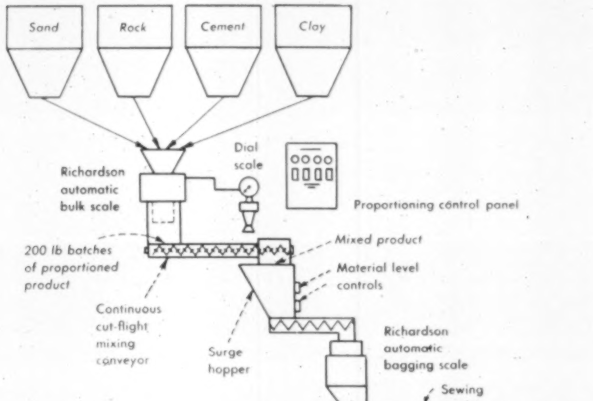

FINE BALANCE NUTS
NULL BALANCE INDICATOR
CIRCULAR LEVEL
BEAM PROTECTING COVER
PRESSURE PAN
VACUUM PAN
RIDER BEAM
LEVEL ADJUSTING KNOBS
CENTER TUBE
WEIGHT RACK
VENT COCK
BELL
OUTPUT TUBE TO INSTRUMENT BEING CALIBRATED
BELL CHAMBER
OIL LEVEL PLUG
PINCH COCKS
OIL LEVEL
ASPIRATOR BULBS (PRESSURE & VACUUM)
DRAIN PLUG
REAR LEVELING FOOT & HANDLE OPERATOR
CENTER TUBE DRAIN

The Calibrator is a manually operated pneumatic force balance consisting of a standard chemical weigh scale and an oil sealed bell system. Weights on the scale are balanced against an opposing air pressure in the bell. Thus air pressure in the bell can be used as a standard for the calibration of an instrument. (*From new 4-page Form 52-3, Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago 47, Ill.*)

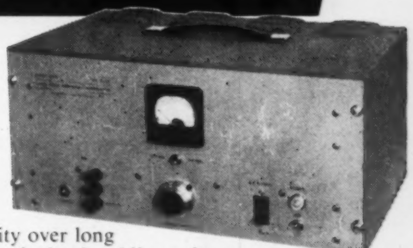
For more literature circle **506** on inquiry card.

Automatic Proportioning

Select-O-Weigh is a development in automatic proportioning equipment which permits the "dialing" of indi-


Sand
Rock
Cement
Clay
Dial scale
Richardson automatic bulk scale
Proportioning control panel
200 lb batches of proportioned product
Mixed product
Material level controls
Continuous cut-flight mixing conveyor
Surge hopper
Richardson automatic bagging scale
Sewing machine
Bags of concrete, mortar, grout or sand-clay mixes
Bagging conveyor

Research-Quality D-C



Extreme stability over long time periods despite load and line-voltage variations or transients . . . that's the prime requirement for a laboratory or quality-control d-c power supply. CEC's new Type 3-132 Low Voltage Regulated Power Supply combines this high precision with unusual convenience and adaptability. It is self-contained, usable anywhere there is 115-volt, 50/60/400-cycle power.

CONDENSED SPECIFICATIONS . . .

Output	0-15 volts d-c at 1 amp (max)
Stability	Less than 5 mv/hr drift
Voltage Regulation	0.1%
Ripple	Less than 1 mv peak-to-peak

For complete specifications, send today for Bulletin CEC1543-X6

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Corporation
ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL
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Sales and Service Offices Located in: Albuquerque, Atlanta, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, Seattle, Washington, D. C.

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MARSHALLTOWN

15
10
20
5
25
30
0
INCHES OF WATER

DIAPHRAGM GAUGE

For Accurate Pressure Measurement in Ounces or Inches of Water

Available in standard dials (reading in inches of water) 0-15" -0-30" -0-60" -0-100" 0-160" . . . also in ounce graduated dials from 15 ounces to 5 pounds. 2½", 3½" and 4½" dial sizes mounted in black enameled steel case.

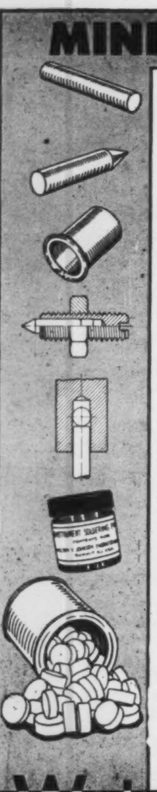
Marshalltown Figure 83 is an extremely sensitive gauge that uses a carefully seasoned bronze diaphragm to accurately measure very low pressures. It is used extensively on many types of natural gas installations for checking low pressures.

Write for details and price. LOOK TO MARSHALLTOWN FOR ONE OF THE MOST COMPLETE LINES OF INDICATING PRESSURE GAUGES MADE!

MARSHALLTOWN MANUFACTURING CO.
MARSHALLTOWN 3, IOWA

For more information circle **100** on inquiry card.

MINIATURE PARTS



CUSTOM MANUFACTURE OF SMALL PARTS

• Shafts, Staffs and Pivots of Special Pivot Steel, Heat-Treated and Metallographic-Polished. • Tubular Products up to ⅜" Diameter, Cut, Flared, Swaged, Formed and Burr-Free Alloy or Silver Plated. • Screw-Machine Products up to 3/16" Diameter. • Roll-Threading and Knurling to Close Tolerances. • Centerless and Surface Grinding with Special Facilities for Ceramic Rods and Shapes. • Light Punch-Press Work.

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• A Multitude of Services are Available for Customers' Parts at Any Stage of Manufacture. These Include: Controlled-Atmosphere Heat-Treating, Centerless Grinding, Surface Grinding, Knurling, Thread-Rolling, Swaging, Drilling, Milling, Burr Removing, Metallographic, Polishing, Barrel-Plating in Alloy or Silver.

ASSEMBLY SUPPLIES

• "Welton" Non-Corrosive Instrument Solder Paste. • "Weltonoil" Treated Buttonwood Pith.

APPARATUS DESIGN SERVICES

In Connection with the Design and Fabrication of Precision Miniature Parts.

ENGINEERING ASSISTANCE ON ALL ITEMS

Welton V. Johnson
ENGINEERING COMPANY INC.
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For more information circle **101** on inquiry card.

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Two to five years aircraft vibration experience required. Shock and vibration theory and a practical knowledge of electromechanical shaker application as used in experimental research testing of complete airframes for flutter analyses and component investigation essential. Familiarity with usage of accessory electronic instrumentation equipment desired. Graduate with M.E. or A.E. degree preferred.

Please address complete resume, outlining details of your technical background, to:

Mr. R. L. Bortner
Administrative Engineer

REPUBLIC AVIATION
FARMINGDALE, LONG ISLAND, NEW YORK

BRIEFS—CONTINUED

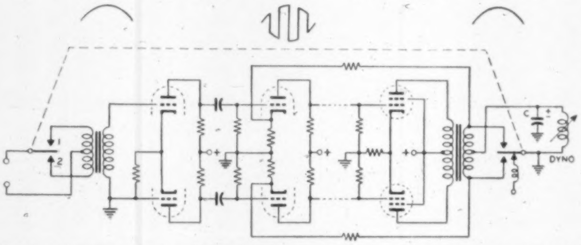
vidual ingredient weights in a formula. Weight selector dials are arranged on a control panel (usually remote from the automatic scales), and are equal in number to the maximum number of ingredients used at any one time.

Integral with the Select-O-Weigh System can be remote indicating of scale weighings on the control panel, as well as remote recording and remote printing of each draft. (*From new 28-page Bulletin* 0351, *Richardson Scale Co., Clifton, N. J.*)

For more literature circle **507** on inquiry card.

Dynograph Oscillograph

The Offner Dynograph direct-writing oscillograph features: sensitivity up to 15 microvolts d-c per mm; drift-free; one-percent linearity; rapid pen response—1/120 second deflection time; no warm up.

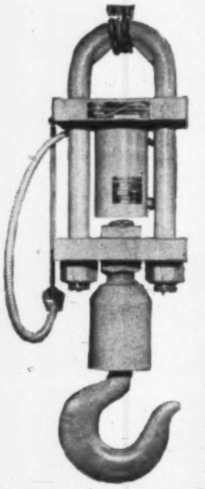


The response and versatility is made possible by the chopper amplifier design . . . a large amount of feedback is employed to give an output impedance of less than one ohm. Frequency response is within ten percent to 70 cps. (*From new 8-page Bulletin* L-742, *Offner Electronics Inc.*, 5320 *N. Kedzie Ave., Chicago* 25, *Ill.*)

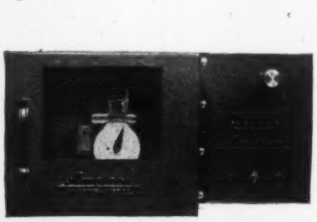
For more literature circle **508** on inquiry card.

New Ametron®

ELECTRONIC CRANE SCALE



Weighs heavy loads suspended from crane hook. Printer, located in crane cab or other convenient location, records weight on tape or cards. New compact printer only 22" x 18" x 10½". Entire assembly designed for prompt and easy installation. Now available at new low cost. Capacities 5 10 15 tons



Write for free Ametron Brochure K-3

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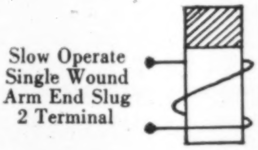
THE STANDARD OF ACCURACY SINCE 1888

Branches in Detroit, Pittsburgh, Allentown, Birmingham and Los Angeles

For more information circle **102** on inquiry card.

Relays, Actuators



The wire used for winding coils is generally referred to as magnet wire. Insulation on magnet wire is usually a thin enamel film having high dielectric strength and efficient winding qualities. Whenever conditions call for temperature higher than the limit for plain enamel insulation, other types of insulation such as Formvar, silk, nylon, glass or silicone impregnated coverings are used.

In almost all cases coils are wound with copper magnet wire as recommended. However, where the requirement calls for a relative high resistance with minimum turns, then resistance wire is used. Advance resistance wire having a very small temperature coefficient is often used in series with copper wire to make a relay operate within narrow voltage limits, yet not be affected by temperature variations to the extent found in an all copper wound coil.

A non-inductive winding in multiple with an inductive winding may be used to operate a relay on half wave rectified current. (*From new 54-page catalog, "Relays and Actuators," Phillips Control Corp., Joliet, Ill.*)

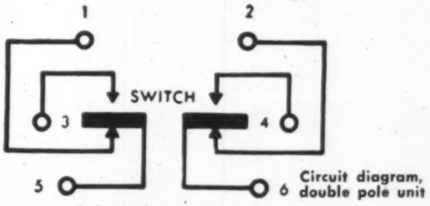
For more literature circle **509** on inquiry card.

Magnetic Tape Data Recording

Basic in our equipment is the concept of wow and flutter compensation as a "must" in all analog data recording. Compensation achieves results with respect to signal-to-noise ratio and data accuracy which are so valuable, in relation to the cost, that it should never be ignored or omitted. Compensation can be applied to any system of

NEW!
AGASWITCH
TRADEMARK
...to introduce time delays into electrical circuits

AGASWITCH
TIME DELAY SWITCH
PATENTED PATENTS PENDING
SERIAL NO.
ELIZABETH AGA NEW JERSEY



Circuit diagram, double pole unit

- Adjustable—time delays from 0.1 second to 5 or more minutes
- Manually operated, pneumatically timed
- Only 3½" x 2½" x 2½" overall
- Both single and double pole types
- Accurate, adaptable, compact and inexpensive

Write for details or application engineering assistance. Address Dept. A6-49.

AGA DIVISION
ELASTIC STOP NUT CORPORATION OF AMERICA
1027 Newark Avenue, Elizabeth, New Jersey
Pioneers in pneumatic timing

For more information circle **103** on inquiry card.

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Stamped Gears

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SEND TODAY *for useful 4-page folder . . a valuable guide to all that is best in the mass production and use of low-cost Stamped Gears, Tools and Assemblies. Many various types are described. Also contains technical data, tables, ideas, suggestions. Use company stationery, please!*

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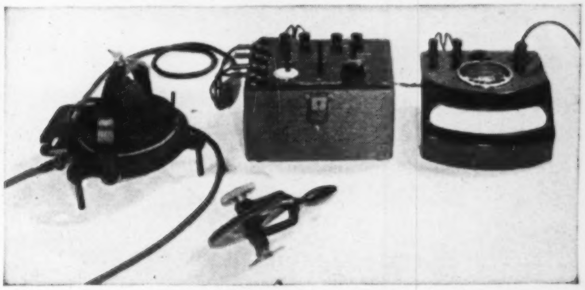
For more information circle **104** on inquiry card.

FOR TESTING FABRICS THAT MUST HOLD GAS



The Cambridge Fabric Permeameter is an accurate, rugged and convenient instrument for production testing of the permeability of fabrics which are to be inflated with Hydrogen, Helium, Carbon Dioxide, etc.

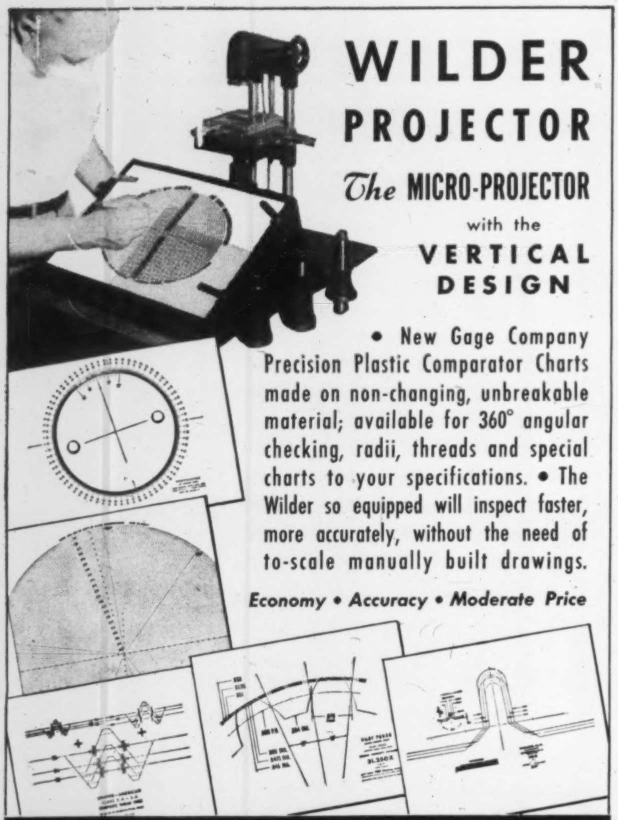
The rate of permeation through the fabric is quickly determined by equipment utilizing the thermal conductivity method and is indicated in terms of liters per square meter per 24 hours of the retained gas.

Manufacturers of fabrics for lighter-than-air Craft, Life Rafts, Life Jackets, Gas Masks, etc., will find this an indispensable instrument. Send for particulars.

CAMBRIDGE INSTRUMENT CO., INC.
3742 Grand Terminal, New York, N.Y.

CAMBRIDGE FABRIC PERMEAMETER

For more information circle **105** on inquiry card.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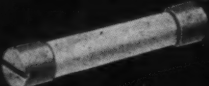
The MICRO-PROJECTOR
with the
VERTICAL DESIGN

• New Gage Company Precision Plastic Comparator Charts made on non-changing, unbreakable material; available for 360° angular checking, radii, threads and special charts to your specifications. • The Wilder so equipped will inspect faster, more accurately, without the need of to-scale manually built drawings.

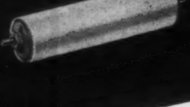
Economy • Accuracy • Moderate Price

Geo. SCHERR OPTICAL TOOLS, Inc.
200-MG LAFAYETTE ST. • NEW YORK 12, N. Y.
For more information circle **106** on inquiry card.

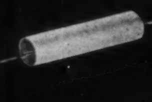
INTERNATIONAL
HIGH VOLTAGE *Selenium Rectifier* CARTRIDGES


FERRULE TERMINAL • phenolic tubing

the WIDEST RANGE in the INDUSTRY


STUD TERMINAL • phenolic tubing

SPECIFICATIONS
DC output voltages from 20 to 20,000 volts and up. DC output current, half wave from .2 MA to 195 MA. Cell diameters from 1/16" to 1" Cartridge lengths from 1/2" to 12"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APPLICATIONS
Computors, geiger counters, guided missiles radar circuits, oscilloscopes
Hermetically sealed units available for airborne applications.

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For more information circle **107** on inquiry card.

analog data recording which is extant today, and to many systems which at the moment are only ideas. Compensation methods have been used most extensively in FM carrier recording, but this should not be interpreted to mean that they are applicable only to this system. We have yet to hear of a data recording method to which wow and flutter compensation cannot be applied, the cost invariably being far less than the cost involved in the "head-on" attack—that of reducing wow and flutter to an absolute minimum.

The simplest form of compensation in a FM system achieves the following: Eliminates noise due to tape motion irregularities . . . performance is independent of percentage deviation of carrier . . . makes accuracy at 10% of full scale as accurate as at full scale. (*From new 14-page Bulletin 54-D, Davies Laboratories, Inc.*, 4705 *Queensbury Rd., Riverdale, Md.*)

For more literature circle **510** on inquiry card.

Digitizers

The Digi-Coder converts shaft position into discrete electrical contact combinations . . . output is provided directly in decimal, binary, teletype, binary-decimal, or any digital code without resort to further conversion.

Two types are made . . . the C-Z Digi-Coder briefly halts shaft motion for a "static" readout . . . the C-3 permits the drums to remain stationary while the input shaft continues to rotate.

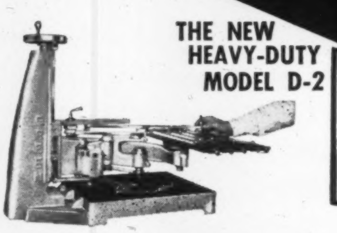
The second basic type, Type P, contains an integral self-balancing potentiometer . . . will operate on a 0 to 1 millivolt input and up.

The input shaft is directly connected to a code drum, on the surface of which are machined hills and valleys forming in effect a number of coaxial cams. Above the code drum is located the sensing block which holds a number

unique in design —
rugged in construction

GREEN
PANTOGRAPH
ENGRAVERS

THE FAMOUS MODEL 106


THE NEW HEAVY-DUTY MODEL D-2

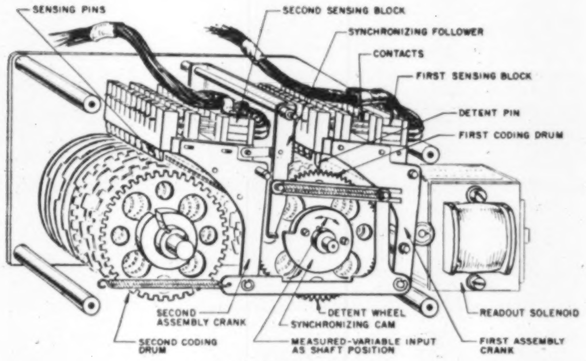
The three-dimensional bench Model 106 cuts costs — engraves, routs, models and profiles, giving you expert results even by unskilled workers.

The Model D-2 two dimensional heavy-duty Pantograph is a precision machine with a multitude of new features. Open on three sides, it permits complete freedom for engraving, milling, profiling large panels (up to 30" in diameter) or bulky pieces. Single, micrometer adjustment controls vertical depth of cut, automatically adjusting copy table with pantograph. Range of reduction ratios from 2-to-1 to infinity! Vertical range over 10 inches!

For complete information, write to

GREEN INSTRUMENT COMPANY
383 Putnam Ave. Cambridge, Mass.

For more information circle **108** on inquiry card.



C-2 DIGI-CODER

of sensing pins which can actuate simple on-off electrical contacts.

When a readout is required, a readout solenoid, electrically actuated, pulls the first assembly crank to bring the sensing block down to the code drum such that all sensing pins are either in or out, depending on their respective hills and valleys on the code drum. In this position of the sensing block, the output thus consists of a number of closed electric circuits and a number of open circuits. Since every position of the input shaft places a unique configuration of hills and valleys beneath the sensing pins, the open and closed circuits leaving the sensing block are, in essence, a coded digital expression of the value of the measured variable represented by the input shaft position at time of readout. (*From new* 12-*page Catalog* 58-10, *Fischer & Porter Co., Hatboro, Pa.*)

For more literature circle **511** on inquiry card.

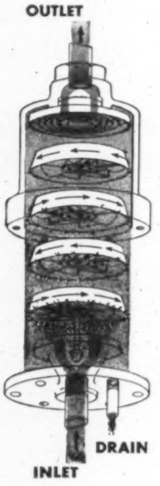
Instrument Field As A Career

What is the Instrument and Control Industry? Where are Instruments and Controls Used? What Kinds of Engi-

EQUIPMENT LASTS LONGER
. . . PERFORMS BETTER . . .
when the

ARIDIFIER

SCRUBS, CLEANS AND DRIES
On Air and Gas Lines

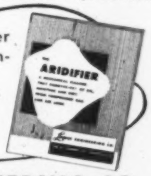


LASTS LONGER because . . .
The Aridifier's patented centrifugal-baffle action traps 92% of all dirt, oil, scale and water in gas or compressed air . . . and drains off these troublemakers *before* they can damage tools and equipment.

PERFORMS BETTER because . . .
The Aridifier protects tools against the freezing, fouling, caking and corrosion caused by dirt and foreign matter . . . assures the clean, dry air and gas that means better spray work, painting, lacquering, sand blasting, air cleaning, and similar operations.

Easily installed, the Aridifier maintains itself. 10 models. Capacity range; 7 CFM to 17,000 CFM.

Learn HOW the Aridifier scrubs with a patented centrifugal-baffle action.
Write for This Catalog Now!



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For more information circle **109** on inquiry card.

throw out obsolete testing

Cut Production Rejects and Re-work as much as 47%
Streamline Preventive Maintenance
Speed Up Trouble Shooting
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Streamline Volt-Ohm-Mil-Ammeter—quick, accurate checks on voltage, current and resistance

Uses minimum bench space—3-7/32" x 5-1/2"—only 4 lbs.—completely portable for all preventive maintenance and electrical trouble shooting—laboratory instrument precision

Operation is completely streamlined—one switch for both circuit and range selection

630 VOLT-OHM-MIL-AMMETER

$39.50 net

33 RANGES

D.C. VOLTS:
0-3-12-60-300-1200-6000, at 20,000 Ohms/Volt. (For greater accuracy on TV and other High Resistance Circuits.)

A.C. VOLTS:
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D.C. MICROAMPERES:
0-60, at 250 M.V.

D.C. MILLIAMPERES:
0-1.2-12-120, at 250 M.V.

D.C. AMPERES:
0-12, at 250 M.V.

D.B.:
−30, +4, +16, +30, +44, +56, +70. (For Direct Reading of Output Levels.)

*OHMS:
0-1000-10,000 (4.4-44 center scale).

*MEGOHMS:
0-1-100 (4400-440,000 Ohms center scale).

TRIPLETT
ELECTRICAL INSTRUMENT COMPANY
Bluffton, Ohio

For more information circle **110** on inquiry card.

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low cost
... inventory
... installation
... maintenance

miniature
... for space economy

maximum circuit flexibility
... more than 145 electrical arrangements

An entirely new concept in automatic time interval control, Atcotrol is designed to be the standard in its field.

Requires but one clearance hole for mounting. Atcotrol timer can be demounted from panel in 2 seconds without tools. Completely serviced with a screwdriver. Either reset or stop on power failure. Motor, clutch and reset operation visible from front. Instantaneous reset. No pointer rebound. Built to NEMA standards. Conservatively rated at 10 amps. *Repeat accuracy within .1 of 1%.* Many other new and exclusive features.

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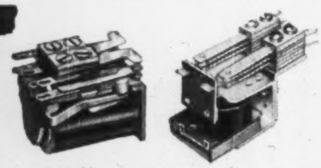
ATCOTROL
RESET TIMERS

For more information circle **111** on inquiry card.



more relay for your money

Yes, you get *more* for your relay dollar from Comar. You get *top quality* relays, precision engineered for peak performance. You get *dependable* relays, job-tested and job-proved.

You get relays "*custom-manufactured*" to your specs. You get the *exact* characteristics, sizes and mountings to fit your needs. You get *fast* service. Complete manufacturing and sealing facilities are all coordinated in one modern plant. You *save* time and money.

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3349 ADDISON STREET
CHICAGO 18, ILLINOIS

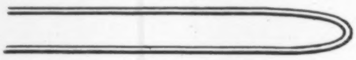
RELAYS • SOLENOIDS • COILS • TRANSFORMERS • SWITCHES • HERMETIC SEALING

For more information circle **112** on inquiry card.

neering are Available in the Instrument and Control Industry? What is the Opportunity for the Future? (*From new 6-page folder "Your Career with the Instrument and Control Industry," Recorder-Controller Section, SAMA, 522 Fifth Ave., New York 36, N. Y.*)

For more literature circle **512** on inquiry card.

Thermoelements

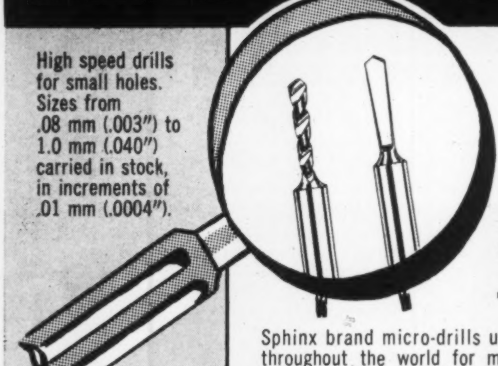


Platinum vs. platinum-rhodium thermoelements are reliable to a degree which permits their use as standards . . . are accurate and stable in calibration even when subjected to temperatures up to 2900 F either cyclically or for prolonged periods.

Two kinds are available: platinum vs. 90% platinum and 10% rhodium, and platinum vs. 87% platinum and 13% rhodium. The range over which both types may be used is the same, but they differ somewhat in millivolt output and inherent stability . . . the 10% alloy is more refractory and thus retains its calibration for a longer period, while the 13% alloy has the higher millivoltage output. For high accuracy the use of such an element in the lower temperature ranges should not be overlooked.

Of the base metal group, the chromel vs. alumel thermoelement has come to have the widest application because of its stability and high output, chemical use and wide range (up to 2400 F). (*From new 6-page brochure "Thermoelements Noble and Base Metals," Charles Engelhard, Inc., 850 Passaic Ave., E. Newark, N. J.*)

For more literature circle **513** on inquiry card.



"IN-STOCK" SERVICE ON FAMOUS SPHINX BRAND MICRO-DRILLS

High speed drills for small holes. Sizes from .08 mm (.003") to 1.0 mm (.040") carried in stock, in increments of .01 mm (.0004").

Sphinx brand micro-drills used throughout the world for many years for all fine watch and instrument work.

Send for Bulletin N listing sizes and prices of stock drill sizes and micro-drilling equipment.

These precision drills are available in two styles, flat pivot drills or spiral fluted drills. They are made with concentric oversize shanks. Because of their rigidity they are especially useful in all types of drilling equipment.

LEVIN ® Louis Levin & Son, Inc.
3610 South Broadway • Los Angeles 7, California

For more information circle **113** on inquiry card.

Magnet Wire

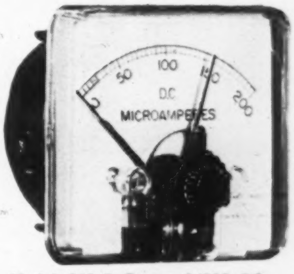
Copper long has been and still is the conducting metal of the electrical industry which uses approximately 55 percent of all the copper smelted in the United States. In recent years, the second choice of the electrical industry is aluminum. Anaconda now produces aluminum wire and cable and certain large sizes of aluminum magnet wire. *(From new 120-page booklet "Anaconda Magnet Wire," including tables for units, fractions, temp. conversions, etc. Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.)*

MULTIPLY	BY	TO OBTAIN
Kilogm-Meters	7.233	Foot-Pounds
	9.8117	Joules
	0.0027235	Watt-Hours
	0.0092944	BTU's
Kg-M per Sec	9.807	Watts
Kilometers	0.62137	Miles
	1,093.611	Yards
	3,280.833	Feet
	39,370.0	Inches
Kilov'lts per Cm	2.54	Volts per Mil
Liters	61.0250	Cubic Inches
	0.0353137	Cubic Feet
	0.2642	Gallons
$\text{Log}_e x$	2.3026	$\text{Log}_{10} x$
$\text{Log}_{10} x$	0.4343	$\text{Log}_e x$
Meters	1.093611	Yards
	3.2808333	Feet
	39.369999	Inches
	100.0	Centimeters
Miles	1,760.0	Yards
	5,280.0	Feet
	1.6093	Kilometers
Millimeters	0.0032808	Feet
	0.03937	Inches
	0.001	Meters

For more literature circle **514** on inquiry card.

METER-RELAYS

For Sensitive and Accurate Control



Model 261-C Range 0/200 DC Microamperes Price $33.00

RANGES:

0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc. These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully. Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases).

Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

Suggested circuits for meter-relays and complete specifications including prices are covered in new 16-page Bulletin G-6, which you can get by writing Assembly Products, Inc., Chesterland 10, Ohio.

"See us at I.R.E. Conf. Westward Ho, Phoenix, 4/28, 29"

For more information circle **115** on inquiry card.

Your kind of . . .

Solenoid Valves

There *IS* something better in solenoid valves—the new Marsh Electrimatic. Bodies machined from solid brass stock mean extra strength, greater dependability. Coils are moisture and frost proof. Valves are tight seating, smooth, positive, quiet. Types for wide range of application: direct acting—or pilot operated for large capacity.

. . . Outline your conditions and we will tell you how we can help you with your Solenoid problems.

MARSH INSTRUMENT CO.
Sales affiliate of Jas. P. Marsh Corp.
DEPT. 42, SKOKIE, ILL.
Export Dept., Skokie, Illinois

For more information circle **114** on inquiry card.

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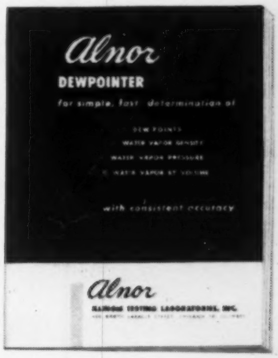
INFORMATIVE BULLETIN

Learn how easy it is for anyone to determine dew points quickly and accurately with the

ALNOR DEWPOINTER!



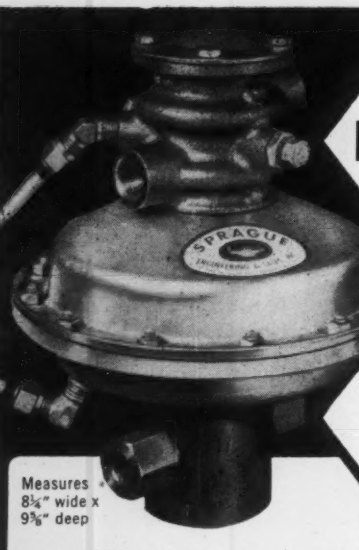
Only the Alnor Dewpointer has a sealed testing chamber, where atmospheres can be analyzed under controlled conditions . . . where the fog is observed *suspended in air* for fast, positive readings. Completely self-contained and readily portable for laboratory accuracy anywhere in the plant or field. And simple, direct operation enables even nontechnical personnel to easily obtain precise results, time after time.

Tear out this ad and send it along with your business letterhead to Illinois Testing Laboratories, Room 518, 420 N. LaSalle St., Chicago 10, Ill.

Alnor

PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information circle **116** on inquiry card.



HIGH PRESSURE PUMP

air driven

FOR PRESSURES TO 30,000 PSI

Measures 8¼" wide x 9⅜" deep

Boost 100 PSI. air pressure to 10,000 PSI. fluid pressure for $173.25 (FOB Gardena, Calif.). Eight standard models for output fluid pressures of 1,000 to 30,000 PSI. Special models for lower or higher pressures.

Applicable wherever low volume output at high pressures is the requirement. For oil or water service. Complete power packages also available. Send for bulletins.

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Engineering Corporation
1144 WEST 135TH STREET, GARDENA, CALIFORNIA

For more information circle **117** on inquiry card.

Cramer
INTERVAL TIMERS

. . . manually set, over full dial range. Controls the opening of one circuit and closing of another for a selected time interval. For ovens, copying machines, process controls, automatic mixers, etc.

For full story, write today for descriptive folder PB-210, shown above.

The R. W. CRAMER CO., Inc.
BOX 5, CENTERBROOK, CONNECTICUT

Cramer TIMING DEVICES

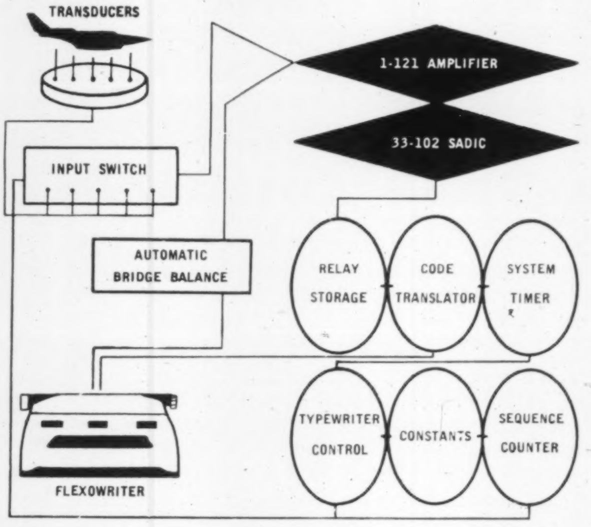
10CR55

For more information circle **118** on inquiry card.

Data Processing

Spectacular proof of the benefits of automatic data processing was evidenced by a new digital system designed and built for Convair Aircraft of Ft. Worth, Texas, by Consolidated's Systems Division.

In just two weeks, during a single test series on a pressure-survey wind-tunnel model, the saving of a substantial portion of the cost of the $150,000 revolutionary, electronic pressure-measuring system was realized. In addition, tabulated wind-tunnel-test data reached the hands of design engineers in Ft. Worth within 48 hours after the tests were run. This is a striking contrast to the 45 days formerly required by the laborious process of reading and tabulating manometer-tube photographs.



Convair's aeronautical engineers estimated that the labor involved in reducing the 6,000,000 manometer-tube data points to usable form would have amounted to $108,000. Cost alone was not the only consideration.

CEC's Data-Processing System is designed to automatically measure, digitize, and record the output of 202 pressure pickups and 2 strain-gage supply-voltage indicators. The over-all accuracy of the system is ± 0.75 percent of full-scale pressure (7½psia.) The route of pressure information from the time it is picked up on the aircraft model, through the series of data-processing operations, until a written record appears, is shown here. (*From new Vol. 9 No. 1 issue of CEC Recordings, Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.*)

For more literature circle **515** on inquiry card.

Slip Rings

P M Industries has specialized in designing and producing electromechanical instrument components . . . . particularly slip ring assemblies (from 8-foot 500-ring assemblies down to miniatures for synchros, gyros, and resolvers).

Typical applications include Gyro (9 circuits), Strain Gage (80 circuit), Radar (103 circuits), Gun Fire Control (531 circuits).

Typical specifications: high voltage—25,000 Volts DC Corona Free; low voltage—strain gage and thermocouple applications; power—up to 600 amperes; RF crosstalk—50 db at 60 Mc. (*From new 4-page brochure, P-M Industries, Inc., Stamford, Conn.*)

For more literature circle **516** on inquiry card.

Books...

Basic Circuitry of the Midac and Midsac, *by J. E. DeTurk, et al,* University of Michigan Press, Ann Arbor, Mich., 1954, $2.00; 116 pages, nonmathematical, cover basic design features and circuits of digital computers.

Regelungstechnik, assembled by the Automatic Control Committee of the Verein Deutscher Ingenieur and the Verband Deutscher Electrotechniker. Published by Deutscher Ingenieur-Verlag, GMBH, Duesseldorf 10, Germany, 1954. Paper, 282 pages, Price: 24 DM. Comprises 28 papers classified under: Fundamentals, Control Techniques, Applications of Controls in Process Industries, Rolling Mills, etc.

Cook Technical Review, Vol. 1, No. 1, Cook Research Labs, 2700 N. Southport Ave., Chicago 14, Ill.; paper, 113 pages, $1.00. Comprises 7 papers on servomechanism design, nonlinear techniques, saturating servomechanisms, etc.

Sonics, *by T. F. Hueter and R. H. Bolt,* J. Wiley & Sons, 440 Fourth Ave., N. Y. 16, N. Y., 1955, 456 pages, cloth, $10.00. Eight chapters plus appendix cover principles and applications of sound and ultrasonics, including transducers, processing, analysis, etc.

Transistor Audio Amplifiers, *by R. F. Shea,* J. Wiley & Sons, 1955, cloth, 219 pages, $6.50. Eight chapters cover transistor fundamentals and parameters, preamplifiers, power amplifiers, etc.

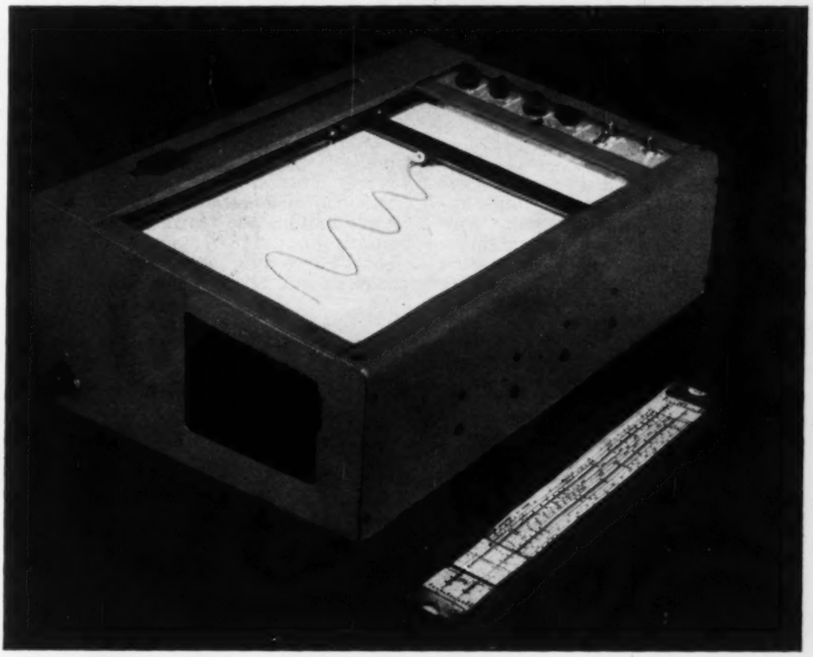
Recurrent Electrical Transients, *by L. W. Von Tersch and A. W. Swago,* Prentice-Hall, Inc., 70 Fifth Ave., N. Y. 11, N. Y., 1954, 400 pages, $10.35. Nine chapters comprise basic text on basic R-C-L circuits, clamps, clippers, deflection circuits, triggers, and multivibrators.

Correction

Dear Sir:
I would like to point out an error in Table 1 on page 451 of the March, 1955 issue of *Instruments and Automation.* The freezing point of air-saturated distilled water is 0.000 deg. C, since this is a "fixed point" defined by the International Temperature Scale of 1948. The freezing point of air-free distilled water would then be +0.0023 deg. C. (and not −0.0023 as indicated in the table).

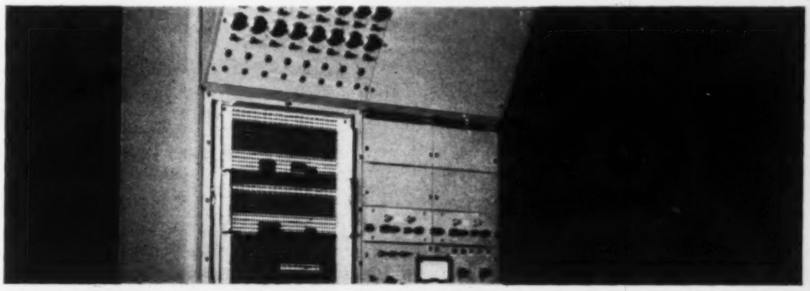
ARGONNE NATIONAL
LABORATORY
Lester F. Coleman
Chemical Engineering Division

News in X-Y Recording



The new Variplotter Model 1100 Plotting Board

Including vacuum hold-down for plotting paper, finer accuracy, faster response



For use with Precision Analog Computing Equipment, Digital Systems, Instrumentation, etc.

Variplotter Model 1100 — Provides rapid (pen slews at approximately 20" per second) graphic recording of any data that can be reduced to electrical form. Same reliable accuracy as the well-known 205 series Variplotter. Ideal where compactness is essential without loss of speed or performance. Designed for use in recording computer outputs (as with EAI 16-31R pictured above), generating functions, or with additional equipment — for plotting digital information from punch cards or tape. For complete brochure write Department IA7, Electronic Associates, Inc., Long Branch, New Jersey.

ELECTRONIC ASSOCIATES Incorporated

EAI SETS THE P A C E — PRECISION ANALOG COMPUTING EQUIPMENT

LONG BRANCH, NEW JERSEY

For more information circle **119** on inquiry card.

New Literature...

For literature use the postage-free order card on page 667.

AUTOMATION

Pneumatic Controllers. New 44-page Bulletin 1120 is basic handbook covering principles, operation, and applications of maker's pneumatic controllers and transmission systems—cascade, ratio and other interconnected control systems.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **517** on inquiry card.

Pneumatic Ratio Relay. New 4-page Bulletin 8410 describes maker's automatic ratio relay used in ratio control, cascade control, pneumatic computing systems, etc.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **518** on inquiry card.

Reactor Control. New 8-page Booklet ND46-70-700(1) pictures and describes maker's control systems for nuclear reactors.—Leeds & Northrup Co., 4907 Stenton Ave., Philadelphia 44, Pa.

Circle **519** on inquiry card.

Load, Frequency Control System. New 12-page Bulletin 9060 presents electric-system load and frequency control system using maker's servo controllers.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **520** on inquiry card.

Combustion Control. New 14-page Bulletin MSA 116 presents descriptions and pictorial diagrams on various application of control equipment as boilers increase in size. Includes thorough discussion of combustion-control principles and applications.—Hagan Corp., 323 Fourth Ave., Pgh., Pa.

Circle **521** on inquiry card.

Automatic Control Services. New 8-page bulletin describes consultation, design, and construction services offered by control engineering specialists in fluid mechanics, servo mechanisms, computers, electronics and basic measurements of properties of matter. —CDC Control Services, Inc., 400 S. Warminster Rd., Hatboro, Pa.

Circle **522** on inquiry card.

Lathe Stop. New 4-page descriptive bulletin illustrates maker's "Sure-Stop" turret indicator stop for maintaining close length tolerances in duplication of machined parts.—D-S-C Machine Co., 29 Bertel Ave., Mount Vernon, N. Y.

Circle **523** on inquiry card.

MOTORS, SERVOS

Synchronous Motors. New 24-page Brochure EI-4A presents physical specifications and electrical characteristics of maker's synchronous, hysteresis and salient pole induction motors. —Electric Indicator Co., Inc., Springdale, Conn.

Circle **524** on inquiry card.

Synchronous Motors. New 34-page Catalog 41 describes and illustrates maker's autosyns and magnesyns, a-c series motors, d-c selsyns, servo motors, motor generators, timing motors, cycle motors and blowers, linear actuators, shunt motors, power generators, etc.—Servo-Tek Products Co., Inc., Hawthorne, N. J.

Circle **525** on inquiry card.

Servo Motors, Servo Components. New 36-page Catalog 954 describes and illustrates maker's miniature PM motors and accessories, miniature wound motors and field accessories, fans and blowers, a-c motors, potentiometers, thermocouples, pressure and temperature switches, etc.—Burton Mfg. Co., 11201 W. Pico Blvd., Los Angeles 64, Calif.

Circle **526** on inquiry card.

Servo Motors. Two new 2-page Bulletins 2464 and 2395-5 describe maker's servo motors, motor generators, miniature a-c servo motors and tachometer generators.—G-M Laboratories, Inc., 4300 Knox Ave., Chicago 41, Ill.

Circle **527** on inquiry card.

Motors. New 4-page Leaflet F-4271-5 describes and illustrates maker's small motors for domestic appliances, communication equipment, industrial instruments, servomechanisms.—Barber-Colman Co., Rockford, Ill.

Circle **528** on inquiry card.

Electric Motors. New 4-page issue of "Bodine Motorgram" (Vol. 35, No. 1) features article on "Ball Bearing Lubrication."—Bodine Electric Co., 2250 W. Ohio St., Chicago 12, Ill.

Circle **529** on inquiry card.

VALVES, CYLINDERS

Valve Assemblies. New 6-page Bulletin 8506 describes maker's electric motorized valve assemblies which are combinations of globe or butterfly valve bodies, linkages where needed, and electric power units.—Industrial Div., Minneapolis Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **530** on inquiry card.

Valves. New 12-page comic-book-type sequence explains maker's "Shear-Seal" principle for controlling fluids-under-pressure or vacuum.—Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle **531** on inquiry card.

Pipeline Valves. New 4-page issue of "Haynes Alloys Digest" (Vol. 6, No. 3) features article on "Hard-Faced Pipeline Valves Still Good After 17 Years."—Haynes Stellite Co., 30-20 Thomson Ave., Long Island City 1, N. Y.

Circle **532** on inquiry card.

Hydraulic Cylinders. New 8-page Bulletin H-104K describes and illustrates maker's 2000 psi high-pressure hydraulic cylinders in 1½ in. through 12 in. bores.—Miller Fluid Power Co., 2040 N. Hawthorne Ave., Melrose Park, Ill.

Circle **533** on inquiry card.

Air Cylinders. New 8-page Bulletin A-105K presents engineering, mounting and dimensional data on maker's 200 psi air cylinders with rustproof brass barrels, hard chrome-plated piston rods, etc.—Miller Fluid Power Co., 2040 N. Hawthorne Ave., Melrose Park, Ill.

Circle **534** on inquiry card.

Hydraulic Equipment. New 20-page booklet "J.I.C. Hydraulic Standards" presents all revisions made at Jan. 1954 meetings of the Joint Industry Conference. Includes recommended practices on hydraulic packings and seals, examples of packing code identification, etc.—Miller Fluid Power Co., 2040 N. Hawthorne Ave., Melrose Park, Ill.

Circle **535** on inquiry card.

Valves. New 8-page Catalog 1154 presents description, illustrations, and applications on maker's pinch-type, hand operated, air operated and airveying valves.—RKL Valves & Mfg. Co., 1623 Elaine St., Phila. 19, Pa.

Circle **536** on inquiry card.

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Your present machines can be equipped with full automation, including automatic loading and gauge feedback control of size.

SPECIALISTS IN CENTERLESS GRINDER AUTOMATION.

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Cincinnati 36, Ohio

TEMPERATURE

Thermometers. New 4-page Specification Sheet 602 describes and illustrates maker's internal cam programmer thermometers for maintaining definite relationship between temperature and time.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **537** on inquiry card.

Temperature Control. New 4-page Data Sheet 643 (3) describes maker's roof-temperature measurement using target-brick method. 4-page Data Sheet 643 (4) describes maker's roof-temperature measurement using direct-sighting method.—Leeds & Northrup Co., 4907 Stenton Ave., Phila. 44, Pa.

Circle **538** on inquiry card.

Temperature Control. New 2-page Bulletin 334 describes maker's "Model LD-1S" indicating temperature control for industrial ovens, liquid baths, dryers, etc.—Burling Instrument Co., 16 River Rd., Chatham, N. J.

Circle **539** on inquiry card.

Paper Thermometers. New 6-page folder describes maker's paper thermometer for determining temperatures in brake testing, molds, plastic heat-sealing machines, irons, etc.—Paper Thermometer Co., 10 Stagg Drive, Natick, Mass.

Circle **540** on inquiry card.

Pipeline Heater. New 4-page issue of "Engineering News" (Vol. 7, No. 1) features article on "Efficient Water Heating Assured by SK Continuous Pipeline Heater."—Schutte and Koerting Co., 18 States Rd., Cornwells Heights, Bucks County, Pa.

Circle **541** on inquiry card.

Temperature Control. New 6-page Bulletin 42 describes maker's "Type E32N" indicating temperature control for controlling and indicating temperatures of gases, liquids or hot plates. —United Electric Controls Co., 85 School St., Watertown, Mass.

Circle **542** on inquiry card.

Lab Thermometers. New 12-page Catalog 55-A presents specifications and prices of over 850 thermometers. Includes A.S.T.M., ground joint, low temperature, midget, deep immersion, bath, distillation thermometers, etc.—Brooklyn Thermometer Co., 217-09 Merrick Blvd., Springfield Gardens, N. Y.

Circle **543** on inquiry card.

PRESSURE

Pressure Controller. New 4-page Bulletin 7404 describes maker's indicating furnace-pressure controller for measuring and controlling furnace operation. — Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa.

Circle **544** on inquiry card.

Pressure Control. New Bulletin I-N-1 describes proper applications and functions for maker's "Model PC" pressure pilot control and "Model ESC" temperature pilot control for applications from -40 to 700 F.—Seely Instrument Co., Inc., Niagara Falls, N. Y.

Circle **545** on inquiry card.

transmission of
pressure
information

MODEL 47155
high output
INDUSTRIAL PRESSURE TRANSMITTER

PRESSURE RANGES

Absolute (psi)	0-15, 0-20, 0-30 0-50, 0-75, 0-100
Gage & Differential (psi)	0-4, 0-10, 0-15, 0-20 0-30, 0-50, 0-75, 0-100 −5 to +5, −10 to +10, −15 to +15

* An improved, low cost, high accuracy version of GIANNINI Pressure Transmitters that have been used for many years in aircraft and missile applications. The Model 47155 has been designed for industrial use and features high outputs (up to 40 volts) that can be used to operate indicating and recording devices without amplification. Precious noble metal alloys are used in the potentiometer winding and wiper for low friction, high resistance to corrosion and long operating and shelf life.

Write for data sheet 47155.

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PRODUCT OF ELECTROMECHANICAL DIVISION
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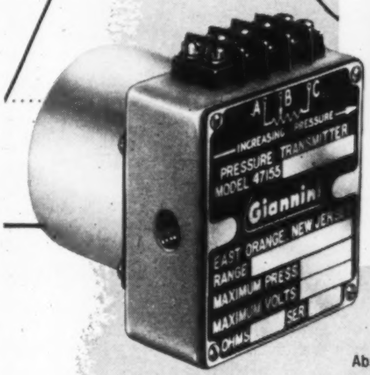

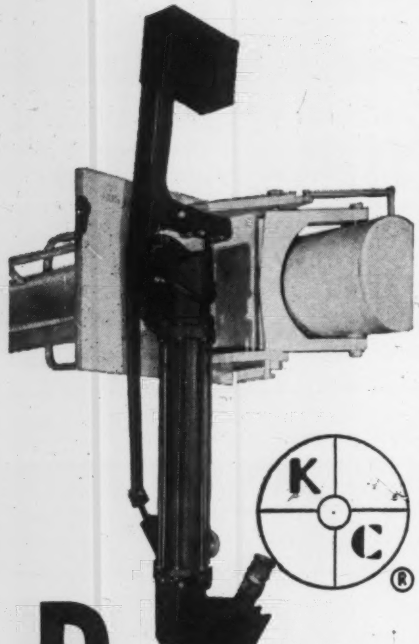

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Remote Observation

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If you have a problem calling for a periscope or for any precision optical system, check with us. For nearly half a century Kollmorgen has designed, developed and manufactured precision optical products including Industrial and Naval Periscopes, Fire Control Devices, Projection Lenses and Navigational Instruments for Industry and for the Armed Services.

Send for Bulletin 301

KOLLMORGEN Optical CORPORATION

Plant: 347 King Street, Northampton, Mass.
New York Office:
30 Church Street, New York 7, New York

For more information circle **121** on inquiry card.

MANUFACTURERS' NEW LITERATURE

Pressure Gage. New 4-page Bulletin 1787 describes and illustrates "Glaser" pressure gage for production, laboratory, test, missile and rocket applications—Designers For Industry, 4746 W. Washington Blvd., Los Angeles 16, Calif.

Circle **546** on inquiry card.

Pressure Gages. New 2 page Specification Sheet 10 presents description on maker's "Models AB-110, AB-130, AB-110S and AB-130S" air-blast-pressure gages for measuring transient pressures of shock waves in air, gases and liquids.—Chesapeake Instrument Corp., Shadyside, Md.

Circle **547** on inquiry card.

Diffusion Pumps. New 8-page bulletin presents operating characteristics and specifications of maker's booster, vacuum, diffusion, mercury vapor and mechanical pumps.—Naresco Equipment Corp., 160 Charlemont St., Newton Highlands 61, Mass.

Circle **548** on inquiry card.

PUMPS

Controlled Volume Pump. New 4-page Bulletin 500 describes maker's "Microflo Pulsafeeder" pump for controlling volume pumping of liquids at micro flow rates of 2400 ml. per hour.—Lapp Insulator Co., Inc., 10 Gilbert St., LeRoy, N. Y.

Circle **549** on inquiry card.

Centrifugal Pumps. New 12-page Bulletin 110 pictures and describes maker's industrial centrifugal pumps for high-pressure applications.—Eastern Industries, Inc., New Haven, Conn.

Circle **550** on inquiry card.

FLOW, LEVEL

Liquid-Level Control. New 20-page Bulletin 1161 describes maker's systems for measuring and controlling liquid level.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **551** on inquiry card.

Flow Indicators. New Data Sheet 253 describes and illustrates maker's line of transparent and reflex sight flow indicators used on pipe lines ½ in. to 2 in. N.P.T.—Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

Circle **552** on inquiry card.

Gas/Air Mixer. New 4-page Leaflet L-700 presents specifications of maker's "Vari-set" proportional mixer with adjustable jet for proportioned gas and air.—Eclipse Fuel Engineering Co., Rockford, Ill.

Circle **553** on inquiry card.

Float-actuated Flowmeters. New 2-page Data Sheet 10.3-4a describes maker's float-actuated flow and liquid-level meter for measuring, indicating, recording, totalizing and controlling flow in open channels.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **554** on inquiry card.

Liquid-Level Control. New 4-page bulletin describes maker's "Level-Master" used for water, gasoline, oil, alcohol and acid level control.—Jo-Bell Products Co., Inc., 4842 S. St. Louis Ave., Chicago 32, Ill.

Circle **555** on inquiry card.

Gas Stabilization. New 12-page booklet features articles on "Natural Gas Stabilization" and "Stabilization at the City Gate."—Cutler-Hammer, Inc., 503 North 12th St., Milwaukee 1, Wis.

Circle **556** on inquiry card.

TIME, COUNT

Time Recorder. New 4-page leaflet describes and illustrates maker's time recorder and totalizer which computes, registers, monitors, and records process or machine operations.—Heat-Timer Corp., 657 Broadway, New York 12, N. Y.

Circle **557** on inquiry card.

Counters, Scalers. New 10-page price list covers maker's scintillation counters, counter accessories, crystals, scalers, scaler accessories, ratemeters, industrial equipment, etc.—R-C Scientific Instrument Co., Inc., 307 Culver Blvd., Playa del Rey, Calif.

Circle **558** on inquiry card.

Interval Timers. New 8-page Bulletin PB-210 describes and illustrates maker's interval timers for controlling opening and closing operations within definite time range.—R. W. Cramer Co., Centerbrook, Conn.

Circle **559** on inquiry card.

Cycling Timers. New 8-page Bulletin PB 510 describes maker's line of cycling timers for repeating definite time cycle or sequence continuously as long as timers are energized.—R. W. Cramer Co., Inc., Centerbrook, Conn.

Circle **560** on inquiry card.

Automatic Counters. New 4-page bulletin describes maker's electrically- and mechanically-actuated counters for recording and automatic regulation of industrial machinery.—Richardson Scale Co., Van Houten Ave., Clifton, N. J.

Circle **561** on inquiry card.

COMPUTING

Data Processing. New 16-page Booklet EL 205A presents maker's techniques, methods and applications of electronic data processing with UNIVAC.—Remington Rand, Inc., 315 Fourth Ave., New York 10, N. Y.

Circle **562** on inquiry card.

Punched Card Machines. New 6-page illustrated Folder TM 930 shows maker's line of punched card machines and their use in preparation of management records and in securing vital financial and operating reports. Twenty five machines described.—Remington Rand, Inc., 315 Fourth Ave., New York 10, N. Y.

Circle **563** on inquiry card.

Converter, Digitizer. New 6-page leaflet describes maker's analog-to-digital converter for automatic high-speed conversion of instrument data. —J. B. Rea Co., Inc., 1723 Cloverfield Blvd., Santa Monica, Calif.

Circle **564** on inquiry card.

Data Reduction. New 4-page bulletin describes maker's "Datrac" data reduction system for automatic control, lab studies, recording and playback of analog signals, etc.— EPSCO, Inc., 588 Commonweath Ave., Boston, Mass.

Circle **565** on inquiry card.

Data Processing. New 32-page issue of "Cook Technical Review" (Vol. 1, No. 2) features articles on "Nonredundant Processing of Continuous Data."—Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.

Circle **566** on inquiry card.

Impact Vector Nomograph. New 4-page leaflet describes maker's "Impact-O-Graph" vector nomograph "Models R, SS, H, HS, HX, HSX" for measuring degree of shock causing damage to a packaged product in transit.—Impact-O-Graph Corp., 1900 Euclid Ave., Cleveland 15, Ohio.

Circle **567** on inquiry card.

Slide Rules. New 30-page Catalog 164-A pictures and describes maker's log slide rules including vector hyperbolic synchro scale, trigonometric, Pickett-Trig conversion, Simplex-Trig, merchants' and business slide rules, etc.—Pickett & Eckel, Inc., 5 S. Wabash Ave., Chicago 3, Ill.

Circle **568** on inquiry card.

RADIOACTIVITY

Radiation Monitor. New 4-page Bulletin 10 pictures and describes maker's portable radiation monitor used in hospitals, decontamination investigations, hot lab health monitoring, etc.—Jordan Electronic Mfg. Co., Inc., 119 E. Union St., Pasadena 1, Calif.

Circle **569** on inquiry card.

Mobile Scintillator. New 2-page bulletin describes maker's "Model SAX 12-A" mobile scintillator counting assembly for radioisotope clinic and laboratory. 2-page Bulletin 12A presents specifications on maker's "Model RAX 12-A Scintiscanner" for producing scintigrams of gammaemitting sources in vivo.—R-C Scientific Instrument Co., Inc., 307 Culver Blvd., Playa Del Rey, Calif.

Circle **570** on inquiry card.

Radiation Measurement. New illustrated bulletin describes maker's "Probitron" Model FAX161X for measuring roentgen and gamma radiation.—R-C Scientific Instrument Co., Inc., 307 Culver Blvd., Playa Del Rey, Calif.

Circle **571** on inquiry card.

RECORDING

Recorder. New 2-page bulletin describes maker's "Autograf" X-Y recorder used as a digital point plotter or curve follower. 2-page Bulletin 7B describes and illustrates maker's "Model 20" d-c voltmeter for check-

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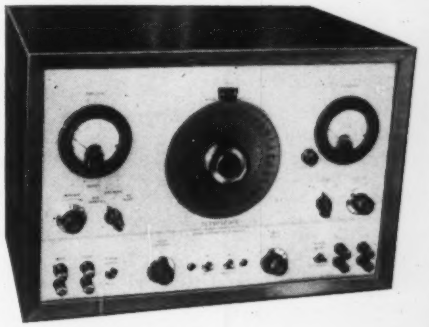

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ing and adjusting computer components.—F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena 3, Calif.
Circle **572** on inquiry card.

Well Logger. New 2-page Data Sheet 7.0-1A describes maker's electrical well logger for recording electrical characteristics of formations traversed by bore holes.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.
Circle **573** on inquiry card.

Recorder. New 2-page Data Sheet 10.17-4 describes maker's system for measuring and recording multiple strain gage outputs in testing of materials, structures and components. —Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.
Circle **574** on inquiry card.

Lab Recorder. New 12-page Bulletin FS-251 describes maker's laboratory recorder for recording changes in potential, current, resistance, temperature, pH, pressure, vacuum, illumination, etc.—Fisher Scientific Co., 711 Forbes St., Pittsburgh 19, Pa.
Circle **575** on inquiry card.

TESTING, INSPECTION

Corrosion Testing. New 2-page Data Sheet 11515 describes and illustrates maker's ASTM copper-strip-corrosion test bomb used in tests of copper corrosion in petroleum products.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.
Circle **576** on inquiry card.

Testing Machine. New 2-page Data Sheet 10.17-5 describes maker's "SR-4" testing machine for testing specimens or structural parts and components in tension, compression, torsion, etc.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.
Circle **577** on inquiry card.

Humidity Chamber. Two new 2-page bulletins describe and illustrate maker's humidity chambers for research and production testing; and low-temperature chamber for testing, storage, metal treating, expansion fitting, etc. —Environmental Equipment Corp., 369 Linden St., Brooklyn 27, N. Y.
Circle **578** on inquiry card.

Testing Instruments. New 4-page Bulletin 505 describes maker's "Models QC-100, QC-125 and QC-200" compression testers for testing cylinders, cubes, blocks, bricks, beams and lintels.—Forney's, Inc., 209 Elm St., New Castle, Pa.
Circle **579** on inquiry card.

Metal Detector. New 4-page Bulletin 15B7217B describes and illustrates maker's a-c electronic metal detector for inspecting plastics, food, confectionery, explosives, glass, etc.—Allis-Chalmers Mfg. Co., 942 S. 70th St., Milwaukee, Wis.
Circle **580** on inquiry card.

Surface Roughness. New 8-page leaflet describes maker's "Profilometer" race-groove pilotor for measuring roughness across raceways of instrument ball-bearing races.—Micrometrical Development Corp., Ann Arbor, Mich.
Circle **581** on inquiry card.

DISPLACEMENT

Displacement Indicator. New 2-page bulletin describes maker's "Model 300" displacement indicator for recording, controlling and indicating quantities measurable by differential transformer transducers.—Daytronic Corp., 216 S. Main St., Dayton, Ohio.
Circle **582** on inquiry card.

Gage. New 2-page bulletin describes and illustrates maker's "Vandy Feeler" gage which uses standard blades. —Vandy-Bilt Tool Co., 301 Walnut Drive., Nashville 5, Tenn.
Circle **583** on inquiry card.

Dynamic Micrometer. New Bulletin T-129-B describes maker's "Dyna-Myke Model 129-E" high-speed dynamic micrometer for linear variable differential transformers.—Industrial Electronics, Inc., 8060 Wheeler St., Detroit 10, Mich.
Circle **584** on inquiry card.

WEIGHT, TENSION

Crane Scales. New 12-page Bulletin 4304 describes crane scales for electrically weighing by "SR-4" load cells. —Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.
Circle **585** on inquiry card.

Tension Gages. New 4-page Leaflet GTL2A describes maker's tension gages for determining tension of any spring up to 2500 grams.—Imtra Corp., 58 Charles St., Cambridge 41, Mass.
Circle **586** on inquiry card.

OPTICS

Light Control. New 4-page Booklet SE 8541 describes maker's "Luxtrol" dial light control for any degree of illumination from complete darkness to full brightness.—Superior Electric Co., Bristol, Conn.
Circle **587** on inquiry card.

Vertical-leveling Mirror. New Bulletin 88108 pictures and describes maker's vertical-leveling mirror that provides reference level lines of sight from front and rear surfaces of double-surfaced mirror.—Farrand Optical Co., Inc., Bronx Blvd. & E. 238th St., New York 70, N. Y.
Circle **588** on inquiry card.

Film Processor. New specification sheets describe maker's "Processall" portable unit for processing of conventional films and papers.—Oscar Fisher Co., Inc., 1000 N. Division St., Peekskill, N. Y.
Circle **589** on inquiry card.

TV Picture Monitoring. New bulletins describe maker's "Private Eye" monitors with frequency response of 8 Mc, electrical centering and focusing, operating from composite and non-composite signals, etc.—Television Utilities Corp., New Hyde Park, L. I., N. Y.

Circle **590** on inquiry card.

AIR, WATER

Steam Contamination. New 6-page Folder 290112 describes dangers of steam contamination and how to prevent or correct them.—Hall Laboratories, Inc., 323 Fourth Ave., Pittsburgh 22, Pa.

Circle **591** on inquiry card.

Moisture. New 4-page leaflet describes and illustrates maker's "Supertest 712" moisture-measuring instrument and "Hygrotester-Boy" portable dielectric-moisture-measuring instrument for converters of pulp, paper, board, cellophane, etc.—Hygrotester, Inc., 51 Clark St., P. O. Box 923, Brooklyn 1, N. Y.

Circle **592** on inquiry card.

Water Softeners. New 20-page illustrated Bulletin 2386-A discusses troubles caused by use of hard water and advantages of using soft water.—Permutit Co., 330 W. 42nd St., New York 36, N. Y.

Circle **593** on inquiry card.

Water Softener. New 4-page leaflet illustrates maker's "Aqua Electric" control which prevents scale-forming elements in water from building up on walls and tubes of equipment.—Aqua Electric Scale Control, Inc., 2028 E. 22nd St., Cleveland 15, Ohio.

Circle **594** on inquiry card.

LAB APPARATUS

Tensiometer. New Bulletin 157 describes and illustrates maker's "Model T-30" surface tensiometer for measuring surface tension of liquids.—National Instrument Labs., Inc., 6108 Rhode Island Ave., Riverdale, Md.

Circle **595** on inquiry card.

Constant-Temperature Bath. New 4-page Bulletin FS-211 describes maker's high-sensitivity constant-temperature bath for viscosity and density tests.—Fisher Scientific, 717 Forbes, Pittsburgh 19, Pa.

Circle **596** on inquiry card.

Lab Carts. New 12-page Booklet C2 pictures and describes maker's laboratory carts. 2-page bulletin describes maker's "Kjeldahl" micro digestor for digestions in 30 ml. flasks.—Laboratory Construction Co., 1115 Holmes St., Kansas City, Mo.

Circle **597** on inquiry card.

Lab Equipment. New 12-page issue of "Lanco Apparatus Review" presents maker's line of balances, beads, beakers, bottle carriers, glass-blowing burners, lab carts, etc.—Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill.

Circle **598** on inquiry card.

Lab Shaker. New bulletin pictures and describes maker's variable-speed laboratory shaker that operates continuously at any rate between 60 and 260 oscillations-per-minute without fluctuation in operating speed.—Eberbach Corp., Ann Arbor, Mich.

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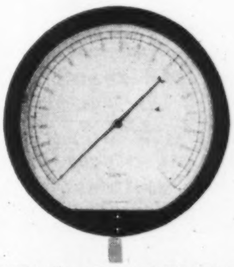

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NEW LITERATURE

Laboratory Apparatus. New 4-page bulletin pictures and describes maker's freeze-drying apparatus, "Extracto-Matic" automatic separatory funnel apparatus for repeated extractions, pipette washer and homogenizers.—VirTis Co., Inc., 160 Ashburton Ave., Yonkers, N. Y.

Circle **600** on inquiry card.

ANALYTICAL

Spectrometer. New 16-page Bulletin 1800C describes and illustrates maker's "Type 21-103C" mass spectrometer for analytical measurement and research.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **601** on inquiry card.

Spectrometer. New 2-page Data Sheet 10.16-19 describes and illustrates maker's "RIDL 2300" scintillation spectrometer used in scintillation crystal testing, x-ray spectrometry, analysis of radioactive mixtures, etc.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **602** on inquiry card.

Fluorescence Analysis. New 16-page issue (Vol. 11, No. 1) of "Norelco Reporter" features article on "Recent Advances in Fluorescence Analysis Instrumentation."—North American Philips Co., Inc., 750 S. Fulton Ave., Mt. Vernon, N. Y.

Circle **603** on inquiry card.

Spectrometer. New 4-page issue of "Spectrographer's News Letter" (Vol. 8, No. 1) describes maker's X-ray scanning spectrometer, Multisource, and ARL Quantograph for spectrochemical analyses.—Applied Research Labs., P. O. Box 1710, Glendale, Calif.

Circle **604** on inquiry card.

Capacitance Analyzer. New Bulletin 154-H1 describes maker's "Model H-04" capacitance product analyzer for continuous recording of pipeline contents, and recording of water content in hydrocarbons by measurement of dielectric properties of material passing electrode.—Instruments, Inc., 122 N. Madison, Tulsa, Okla.

Circle **605** on inquiry card.

X-Ray Spectrography. New 8-page booklet contains reprinted articles on "Determination of Trace Amounts of Iron . . . by Fluorescent X-ray Spectrography."—North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

Circle **606** on inquiry card.

Spectroscopic Analysis. New 8-page folder contains reprinted article on "X-ray Spectroscopic Determination of Columbium and Tantalum in Rare-Earth Ores."—North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

Circle **607** on inquiry card.

Electron Microscope. New 6-page folder describes and illustrates maker's "Model 75KV" electron microscope with magnification range of

1,500 to 15,000 diameters.—North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

Circle **608** on inquiry card.

Spectrograph. New 2-page bulletin is reprint of article "Helium Chamber X-ray Spectrograph."—North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y.

Circle **609** on inquiry card.

Spectrometer Probe. New 4-page issue of "Radio-Frequency Spectroscopy" (Vol. 1, No. 3) features article on "Important New Spinning Sample Technique Improves n.m.r. Resolution."—Varian Associates, 611 Hansen Way, Palo Alto, Calif.

Circle **610** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Plug-in Networks. New 2-page bulletin describes maker's plug-in "Twin T" networks which allow quick change of circuit constants and rapid servicing.—White Instrument Laboratories, 203 Riverside Drive, Austin 4, Texas.

Circle **611** on inquiry card.

Phase Meters. New 6-page issue of "TIC Laboratory Report" (No. 15) describes methods for production testing of helicopter altitude control, amplifier phase shift, and gyro table phasing through use of various types of phase meters.—Technology Instrument Corp., Acton, Mass.

Circle **612** on inquiry card.

VSWR. New 8-page issue of "PRD Reports" (Vol. 3, No. 2) features article on "Impedance Measurements in the 50-1000 MC/SEC Range with a New Standing Wave Indicator."—Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.

Circle **613** on inquiry card.

Resistance Tester. New 8-page Bulletin 1-2 describes and illustrates maker's line of "Vibroground" portable field instruments for measurement of ground resistance, and soil and earth resistivity.—Associated Research, Inc., 3758 W. Belmont Ave., Chicago 18, Ill.

Circle **614** on inquiry card.

Measuring Bridge. New 8-page booklet is manual for high-precision Kelvin-Wheatstone measuring bridge with 5-dial-switch decade resistors.—Donald C. Siebert, P. O. Box 281, Wilmington, Del.

Circle **615** on inquiry card.

Signal Generators. New 2-page bulletin presents description of maker's "Sweepalator" combined signal and sweep generator, and "Decalator Model B" crystal-controlled signal generator.—Decade Instrument Co., Box 153, Caldwell, N. J.

Circle **616** on inquiry card.

Oscillators. New 4-page bulletin presents description, frequency range, and price of maker's sweeping oscillators, random-noise generators, generators for television, pulse and pulsed-carrier generators, marker gen-

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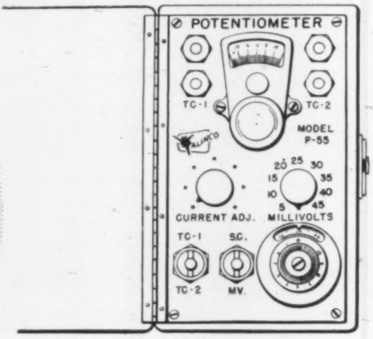

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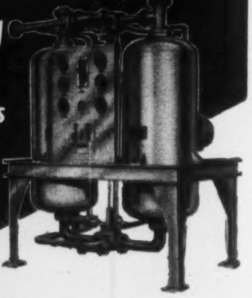

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3.—c	6.—d	9.—b

Book List

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A Bibliographical Survey of Flow Through Orifices and Parallel-Throated Nozzles by T. H. Redding, 1952, cloth, 207 pages. Price $6.00 ☐

Process Control by A. J. Young, 1954, 140 pages, 3-page index. Price $2.00 ☐

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NEW LITERATURE

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Voltage, Current, Flux. New set of bulletins describe and illustrate foreign-made moving-coil instruments for measuring current and voltage in d-c systems; fluxmeters used for measuring magnetic flux and magnetic induction.—Donald C. Seibert, Box 281, Wilmington, Del.
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Radio, Hi-Fi. New 48-page 1955 Catalog 3-55 pictures and describes maker's high-output dynamic microphones, TV boosters, phono-radio combinations, hi-fi equipment, indoor antennas, tool kits, tube testers, etc. —Lafayette Radio, 100 Sixth Ave., New York 13, N. Y.
Circle **619** on inquiry card.

Electronic Components, Equipment. New 16-page catalog "This Month" pictures and describes frequency receivers, watthour meters, miniature immersion pumps, medical stethoscopes, mercury relays, flow control valves, solenoids, transformers, battery chargers, etc., available from distributor.—Herbach & Rademan, Inc., 1204 Arch St., Phila. 7, Pa.
Circle **620** on inquiry card.

Preamplifier. New 8-page issue of "The Right Angle" features article on "Measurement with the Servo Monitor Preamplifier."—Sanborn Co., Cambridge 39, Mass.
Circle **621** on inquiry card.

Bridges, Amplifiers, Pots. New 8-page Bulletin A7 pictures and describes maker's impedance bridges, amplifiers, "Dekaviders", "Dekaboxes", "Dekapots", and "Dekastats". —Electro-Measurements, Inc., 4312 S. E. Stark St., Portland 15, Oregon.
Circle **622** on inquiry card.

Magnetic Amplifiers. New 20-page Booklet 52-600 describes maker's magnetic amplifiers for control applications. Includes tables illustrating component parts, applications, and operating characteristics.—Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.
Circle **623** on inquiry card.

Amplifiers. New bulletin describes maker's "Model ZA-12430" direct-coupled amplifier for lab or instrumentation use.—EECO Production Co., 827 S. Vermont Ave., Los Angeles 5, Calif.
Circle **624** on inquiry card.

Oscilloscope. New 2-page Bulletin 770-1 55H describes maker's "Model 770" oscilloscope for observation of transient or regular recurring phenomena.—Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.
Circle **625** on inquiry card.

Turbine Generators. New 16-page Bulletin GEA-6128 presents description of maker's turbine generators for merchant marine use. Includes construction and design features for passenger ships, cargo vessels, bulk carriers, etc.—General Electric Co., Schenectady 5, N. Y.

Circle **626** on inquiry card.

Magnetic Testing Set. New 4-page issue of "Electrical Measurements" (Vol. 22, No. 1) describes maker's SRIC universal magnetic-testing set for determining B-H curves, hysteresis loops, etc.—Sensitive Research Instrument Corp., Mount Vernon, N. Y.

Circle **627** on inquiry card.

Potential Current Transformers. New 100-page 1955 Buyer's Guide GEC 1028 presents ratings, ASA accuracy classifications, listings of ratio and phase-angle tests, tables of replacement types and prices of all standard G-E indoor and outdoor potential and current transformers.—General Electric, Schenectady 5, N. Y.

Circle **628** on inquiry card.

AC/DC, DC/AC Converter. New 4-page booklet describes and illustrates maker's "Series 300" converter for a-c to d-c or d-c to a-c with laboratory precision.—Quare Associates, P. O. Box 95, Canton, Mass.

Circle **629** on inquiry card.

Volt-Ohmmeter. New Bulletin A-55 describes and illustrates maker's pocket-size volt-ohmmeter with sensitivity of 10,000 ohms-per-volt on both a-c and d-c. Available in fourteen measurement ranges.—Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **630** on inquiry card.

Delay Lines. New 12-page Catalog 54 describes maker's lumped-constant, ultrasonic, and distributed-constant delay lines.—Richard D. Brew & Co., Inc., Concord, New Hampshire.

Circle **631** on inquiry card.

Transistor Circuits. New 24-page issue of "Cornell Dubilier Capacitor" (Vol. 20, No. 2) presents article on "Special-Purpose Transistor Circuits."—Cornell Dubilier Electric Corp., Hamilton Blvd., S. Plainfield, N. J.

Circle **632** on inquiry card.

Panel Instruments. New 4-page Bulletin RUG 230 presents specifications of maker's sealed and ruggedized electrical indicating instruments.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle **633** on inquiry card.

Oscillator. New 8-page issue of "General Radio Experimenter" (Vol. 29, No. 9) features article on "A 900-2000 Mc Unit Oscillator."—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **634** on inquiry card.

Amplifier. New 2-page specification sheet describes maker's differential-transformer amplifier "Model 400" for dynamic study of physical phenomena.—Daytronic Corp., 216 S. Main St., Dayton, Ohio.

Circle **635** on inquiry card.

Oscilloscopes. New 4-page booklet illustrates maker's line of portable

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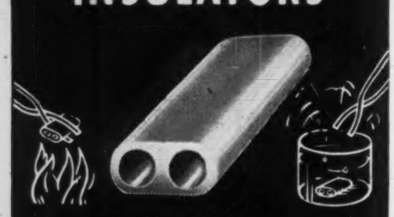

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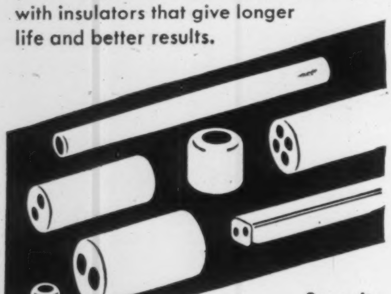

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oscilloscopes, panel-mount oscilloscopes, and waveform monitors.—Probescope Co., 44-05 30th Ave., Long Island City 3, N. Y.

Circle **636** on inquiry card.

Volt-Ohmmeter. New 52-page "Operators Manual" describes maker's "Midgetester" Model 355 ultra-compact, self-shielding volt-ohmmeter for electrical and electronic applications. —Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill.

Circle **637** on inquiry card.

High-current Testing Units. New set of 2-page Data Sheets series 55 describe maker's line of portable, high-current test units for safety checking and calibrating electrically-actuated protective devices.—Multi-Amp Corp., 10 Third St., Newark 5, N. J.

Circle **638** on inquiry card.

Frequency Meter. New 2-page bulletin presents description of foreign-made two-reed frequency meter for determining mechanical vibrations, electrical oscillations and revolutions-per-minute.—Epic, Inc., 154 Nassau St., New York 38, N. Y.

Circle **639** on inquiry card.

BFO Motor Drives. New 8-page issue of "General Radio Experimenter" (Vol. 29, No. 6) features article on "Motor Drives for Precision Dials and Beat-Frequency Oscillators."—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **640** on inquiry card.

Electronic Equipment Export. New 4-page folder describes export company's facilities, special services, products, export-import, packing, transportation procedures, etc.—Terminal Radio International, Ltd., 85 Cortlandt St., New York 7, N. Y.

Circle **641** on inquiry card.

POWER SUPPLIES

Power Supplies. New 8-page bulletin describes sixty-four variations of single and dual power supplies. Includes electrical, mechanical and constructional specifications.—New Jersey Electronics Corp., 345 Carnegie Ave., Kenilworth, N. J.

Circle **642** on inquiry card.

Voltage Controller. New 8-page Bulletin 5.06 illustrates all sizes of maker's "Regohms" voltage controllers. Gives type designations and dimensions for sizes 1 and 3, and includes dimensions for standard sockets and chassis.—Electric Regulator Corp., Norwalk, Conn.

Circle **643** on inquiry card.

Dynamotors. New 6-page Bulletin 410 describes and illustrates maker's "S" and "G" series dynamotors. Includes tables on illustrative ratings and maxima of various frame sizes. 4-page Bulletin 420 presents description of maker's type "K" rotary converter.—Sangamo Generators, Inc., 2110 Clear Lake Ave., Springfield, Ill.

Circle **644** on inquiry card.

Voltage Regulator. New bulletin presents specifications of maker's voltage regulator used as a voltage standard in measuring and controlling circuits to replace standard cells, ballast lamps and calibrating procedures.—C. R. Eckberg Control Instruments, P. O. Box 46, Port Washington, N. Y.

Circle **645** on inquiry card.

Battery Eliminator. New 2-page Bulletin 100 presents description of maker's "Model KM88" aircraft battery eliminator for ground operation and bench testing of airborne equipment.—Opad Electric Co., 69 Murray St., New York 7, N. Y.

Circle **646** on inquiry card.

SWITCHES, RELAYS

Control Switches. New 2-page Data Sheet 920 describes and illustrates maker's remote-control switches for 600 volts a-c and 250 volts d-c.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **647** on inquiry card.

Relays. New 2-page Bulletin 553 presents ratings and selection charts of maker's magnetically- and mechanically-held relays. 4-page Bulletin 708 describes maker's two-way solenoid valves for controlling flow of air, gas, water, light oil and other noncorrosive fluids.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **648** on inquiry card.

Relays. New Data Sheet 555 describes maker's time-delay combination for any standard a-c voltage, made-up of "NEMA 1A" cabinet for general applications indoors, adapter tapped transformer for 240, 480, and 600 volts, and the relay itself.—Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle **649** on inquiry card.

Limit Switch. New 4-page Bulletin LS54A presents electrical, mechanical and maintenance characteristics on maker's "Loxswitch" limit switch.—R. B. Denison Mfg. Co., 102 St. Clair Ave., N. W., Cleveland 13, Ohio.

Circle **650** on inquiry card.

Switches. New Bulletin GS1 presents physical dimensions, contact characteristics, and methods of operation of maker's "E-5600" magnetic dry-reed switch.—Revere Corporation of America, Dept. GS-1, Wallingford, Conn.

Circle **651** on inquiry card.

Step Switch. New 4-page Booklet UNL 3 describes maker's "Both-Way Uniselector" step switch for control and indication circuits.—Imtra Corp., 58 Charles St., Cambridge 41, Mass.

Circle **652** on inquiry card.

Relays. New 12-page Catalog 25-A describes and illustrates maker's telephone-type relays, major, minor and high-voltage relays.—Imtra Corp., 58 Charles St., Cambridge 41, Mass.

Circle **653** on inquiry card.

Sub-miniature Relays. New 2-page illustrated bulletin describes maker's 5 ampere, subminiature, 6-pole, double-throw relays "Series 2005."—Guardian Electric Co., 1621 W. Walnut St., Chicago 12, Ill.

Circle **654** on inquiry card.

Switches. New Data Sheet P96 presents description on maker's environment-proof subminiature switches for operation from −65 deg. F. to +180 deg. F.—Micro Switch Div., Minneapolis Honeywell Regulator Co., Freeport, Ill.

Circle **655** on inquiry card.

RESISTORS, POTENTIOMETERS

Potentiometer. New Data Sheet 54-36 pictures and describes maker's "Series G" potentiometer used in aircraft servo systems and bushing mounting.—Helipot Corp., S. Pasadena, Calif.

Circle **656** on inquiry card.

Potentiometers. New 4-page brochure describes maker's "Type PD-1" dielectric potentiometer for closed-loop self-regulating systems and "Type PD-2" for manual-control video-transmission sets, signal-generator attenuators, etc.—Technology Instrument Corp. 531 Main St., Acton, Mass.

Circle **657** on inquiry card.

Potentiometers. Two new bulletins picture and describe maker's ten-turn sub-miniature precision and sub-miniature trimming potentiometers. Includes electrical, mechanical and environmental specifications.—Daystrom Pacific Corp., 1509 Colorado Ave., Santa Monica, Calif.

Circle **658** on inquiry card.

Resistors. New 6-page brochure describes maker's "Davohm Series 850" hermetically-sealed resistor for aircraft and radar use.—Daven Co., 191 Central Ave., Newark 4, N. J.

Circle **659** on inquiry card.

Potentiometers. New 2-page Bulletins D54-1 and D54-A describe maker's "Types 2134-35 and 2234-35" rectilinear-motion potentiometers for applications where system voltage exceeds that which is desired across potentiometer.—Markite Corp., 155 Waverly Place, New York 14, N. Y.

Circle **660** on inquiry card.

Potentiometers. New 2-page bulletin describes and illustrates maker's "Model RVG-10" precision potentiometer which can be modified physically for special mounting arrangements.—Gamewell Co., Newton Upper Falls 64, Mass.

Circle **661** on inquiry card.

Potentiometers. New set of 2-page bulletins describe maker's precision single-turn potentiometers "Models 100, 200, 300 & 400" with all-aluminum case construction giving stability and high heat dissipation.—Spectrol Div., Affiliated Gas Equipment, Inc., 1704 South Del Mar, San Gabriel, Calif.

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Temperature Test Chamber

For ambient temperature tests in the LABORATORY or on the PRODUCTION LINE, the Model TC-2 Temperature Test Chamber is ideal. Interchangeable extra test trays may be ordered to eliminate loading delays in continuous production tests, or for convenience in special test work.

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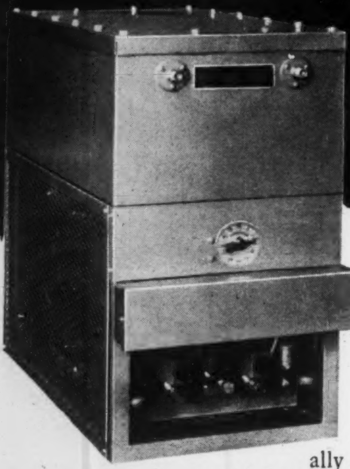

- Produces Constant Supply of clean, dry air to -110°F dew point.
- Automatic operation—requires no attention—no filters or cartridges to clean.
- Sizes range in capacities from 4 CFM, up.
- Mechanically refrigerated unit with 5 yr. warranty.

Now — for the first time, you can get an inexpensive, automatic, mechanically refrigerated Air Drier that will produce air supplies to -110°F dew point! Cleans, drys and delivers air without appreciable pressure loss. The new M & M unit is designed to permit continuous operation and requires no attention or labor to reactivate. Separation of water and oil is accomplished thru condensation.

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NEW LITERATURE

ELECTRONIC COMPONENTS

Wire, Cable. New 34-page Catalog W1 presents illustrations and descriptions on maker's wire and cable products, including jackets, conductors, "Aljak" coaxial cables, miniature and triaxial cables, cable-connector selector, Teflon insulated wires, etc.—American Phenolic Corp., Chicago 50, Ill.

Circle **663** on inquiry card.

Capacitors. New 44-page catalog presents illustrations and tabulated data, specifications, interchangeability list, coding information, etc., on maker's series of paper and foil hermetically-sealed capacitors.—San Fernando Electric Mfg. Co., P 1509 First St., San Fernando, Calif.

Circle **664** on inquiry card.

Selenium Rectifier. Two new Bulletins 6-page H-2 and 4-page "International Rectifier News" (Dec.-Jan. '55) picture and describe maker's high-voltage selenium rectifier cartridges for directing current in high-voltage-low-current applications.—International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Circle **665** on inquiry card.

Diodes. New 4-page Bulletin GD-2 lists ratings and specifications on maker's germanium diodes.—International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.

Circle **666** on inquiry card.

Connectors. New 8-page Brochure R1 pictures and describes maker's line of "Blue Ribbon" connectors with a ribbon-type contact for fast connect and disconnect of mating pairs.—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

Circle **667** on inquiry card.

Bobbin Cores. New 4-page Bulletin BC-102 presents specifications on maker's bobbin cores made of ultra-thin magnetic core materials, wound on small ceramic bobbins.—Magnetics, Inc., Butler, Pa.

Circle **668** on inquiry card.

Air Capacitors. New 16-page Catalog 823 presents mechanical and electrical specifications on maker's precision air capacitors, including midget, single and dual, plug-in, and transmitting capacitors.—Allen D. Cardwell Co., Electronics Productions Corp., Plainville, Conn.

Circle **669** on inquiry card.

Pilot Lights. New 8-page Bulletin OG-A describes maker's "Series 1000" Omni-Glow" pilot lights for industrial applications.—Industrial Devices, Inc., Edgewater, N. J.

Circle **670** on inquiry card.

Connectors. New 12-page illustrated Bulletin R1 describes maker's "Blue Ribbon" connector for electronic subassemblies with low-insertion and withdrawal-force requirements.—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

Circle **671** on inquiry card.

Transformers. New 12-page booklet describes and illustrates maker's hermetically-sealed, mil-type, transistor-type, miniature, sub-miniature, micro-miniature and standard-type transformers.—Microtran Co., 84-11 Boulevard, Rockaway Beach, N. Y.

Circle **672** on inquiry card.

Capacitors. New 6-page Bulletin 337-6 illustrates maker's "Mylar" dielectric capacitors. Includes data on voltage derating for high temperature operation, dielectric material, end seals, etc.—Gudeman Co., 340 W. Huron St., Chicago 10, Ill.

Circle **673** on inquiry card.

Inductance Components. New 2-page Leaflet VI-1154 pictures and describes maker's small, adjustable inductors and a series of i-f transformers for environmental applications due to shock, vibration, moisture, and chemical resistance.—Levinthal Electronic Products, Inc., 2903 Fair Oaks Ave., Redwood City, Calif.

Circle **674** on inquiry card.

Electronic Components. New 16-page leaflet illustrates maker's terminal boards, plastic fabrication, electronic hardware, screw machine parts, standard terminals, etc.—Citation Products Co., 233 E. 146th St., New York 51, N. Y.

Circle **675** on inquiry card.

Wire Seal. Two new 2-page bulletins describe maker's wire seal and support clamp "Series W V" for chafe-free electrical installations.—Thomas Associates, 4607 Alger St., Los Angeles 39, Calif.

Circle **676** on inquiry card.

Tape Resistors. Two new 2-page bulletins describe and illustrate maker's tape resistors for miniature electronic assembly.—Hansen Electronics Co., 7117 ½ Santa Monica Blvd., Los Angeles 46, Calif.

Circle **677** on inquiry card.

COUPLINGS

Tube Fittings. New 132-page Catalog C-100 presents description and illustration of maker's brass tube fittings and pipe fittings, drain and shut-off cocks, "Ermeto" flareless tube and steel fittings, bulk hose and reusable hose ends, hose assemblies with reusable ends, hose assemblies with permanently attached ends, tools, etc.—Weatherhead Co., Cleveland 8, Ohio.

Circle **678** on inquiry card.

Quick Couplings. New 6-page Bulletin 54-1R describes maker's "Pushomatic" quick couplings for air, hydraulic or fluid handling applications.—Breco Mfg. Co., Inc., 309 E. Saratoga St., Baltimore 2, Md.

Circle **679** on inquiry card.

SHOP EQUIPMENT

Soldering Iron. New Bulletin 30H pictures and describes maker's "Featherweight" electric soldering iron for fine soldering on instruments, etc.—Hexacon Electric Co., 161 W. Clay Ave., Roselle Park, N. J.

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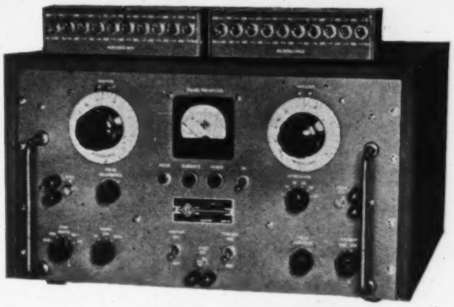

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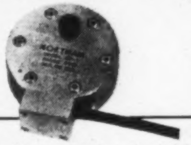

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MODEL DP-7 SPECIFICATIONS:

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Maximum Line Pressure: . . . . 100 psi
Accuracy: . . . . ± 1% full scale
Excitation Frequency: From 60 to 20,000 cps
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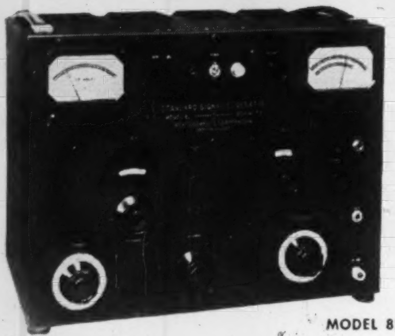

This ONE instrument checks RF, IF, and AF performance of receivers.

Standard Signal Generator

20 cycles-50 mc.

MODEL 82

SPECIFICATIONS:

FREQUENCY RANGE: 20 cycles to 200 Kc. in four ranges. 80 Kc. to 50 Mc. in seven ranges.

OUTPUT VOLTAGE: 0 to 50 volts across 7500 ohms from 20 cycles to 200 Kc. 0.1 microvolt to 1 volt across 50 ohms over most of range from 80 Kc. to 50 Mc.

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POWER SUPPLY: 117 volts, 50/60 cycles. 75 watts.

DIMENSIONS: 15" x 19" x 12". Weight, 50 lbs.

FEATURES:

- Continuous frequency coverage from 20 cycles to 50 mc.
- Direct-reading individually calibrated dials.
- Low harmonic content.
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- Mutual inductance type attenuator for high frequency oscillator.
- Stray field and leakage negligible.
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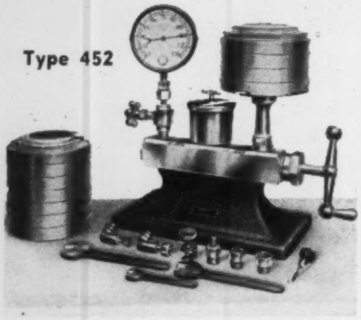
Type 452



Modern design and construction puts this rugged precision instrument in a grade above the ordinary dead-weight testers.

Made in 14 ranges, to 10,000 lbs. maximum.

We guarantee 1/10 of 1 percent accuracy in each range.

The Type 452 is designed for simplicity and compactness. It incorporates the newest refinements and improvements. Adapters and tools are supplied, as well as either carrying case or protecting cover.

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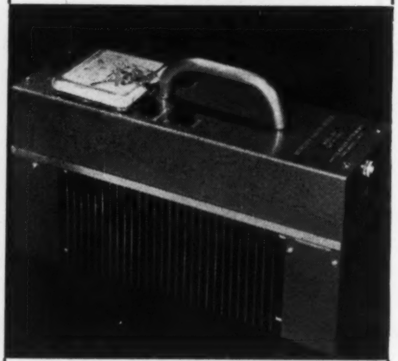
for detecting the toxic vapor given off by mercury



The toxic limit is a full scale reading on the high sensitivity scale Model 23, illustrated above. The weight is 7 pounds and the size is 13 x $8\frac{1}{2}$ x $4\frac{1}{2}$ inches.

A bibliography on the mercury vapor hazard is available on request as well as literature on the different models of the Kruger Mercury Vapor Meter.

HAROLD KRUGER INSTRUMENTS
Box 164 San Gabriel, Calif.

For more information circle **144** on inquiry card.

NEW LITERATURE

Soldering Irons. New 4-page bulletin describes maker's pencil soldering irons with interchangeable soldering tips, molded of red phenolic plastic, feather-light, less than 5-inches long. —Ungar Electric Tools, Inc., P. O. Box 312, Venice, Calif.

Circle **681** on inquiry card.

Wire Brushes. New 4-page leaflet illustrates maker's twisted wire brushes, including standard and special, hand or power driven.—Mill-Rose Co., 1985 E. 59th St., Cleveland 3, Ohio.

Circle **682** on inquiry card.

Industrial Shelves, Lockers. New 24-page catalog presents maker's line of steel shelving, lockers, storage and maintenance equipment for industrial and institutional use.—Precision Equipment Co., 3636 N. Milwaukee Ave., Chicago 41, Ill.

Circle **683** on inquiry card.

Work Benches. New 4-page Bulletin SC 120 describes maker's "Model 12 Sterilshield" dust-free work benches for small laboratories and instrument manufacturers. Bulletin SC 140 illustrates "Model 12" for precision equipment manufacturers.—Baker Co., Inc., Maplewood, Maine.

Circle **684** on inquiry card.

FABRICATION, PARTS

Screws, Nuts, Rivets. New 4-page illustrated bulletin describes maker's miniature precision hardware, including instrument screws and nuts, printed circuit and instrument eyelets, flat and split lock instrument washers, etc. —Circon Component Co., 17544 Raymer St., Northridge, Calif.

Circle **685** on inquiry card.

Molded Plastics. New 8-page bulletin presents engineering, designing and manufacturing facilities for maker's custom-molded plastics.—Koch Mfg. Co., 319 Main St., Jackson, Mo.

Circle **686** on inquiry card.

Pads, Blankets. New 4-page folder describes maker's "Jet-Pak" cushioned pads and blankets that prevent shock, abrasion, marring, freezing or dust accumulation.—Jet-Pak, Inc., 859-879 Summer Ave., Newark, N. J.

Circle **687** on inquiry card.

Nameplates. New 4-page booklet "Branded For Life" describes maker's "Metal-Cals" used for trademarking, serial numbering, service labeling, catalog and parts numbering and dial and gage marking.—C & H Supply Co., 415 E. Beach Ave., Inglewood, Calif.

Circle **688** on inquiry card.

Coil Winding. New 38-page bulletin describes maker's lab winders, transformer and heavy-coil winders, wire-tension devices, etc.—Coil Winding Equipment Co., Oyster Bay, Long Island, N. Y.

Circle **689** on inquiry card.

Metal Stampings. New 38-page booklet describes and illustrates maker's facilities for sheet-metal stamping of plate assemblies, standard square and rectangular cases, cover plate assemblies, potting holes and cover stops, etc.—Hudson Tool and Die Co., Inc., 118-122 S. Fourteenth St., Newark 7, N. J.

Circle **690** on inquiry card.

Gears, Grinders. New 188-page catalog pictures and describes maker's designing, engineering and building of tools, dies, jigs, fixtures and machine tools.—Universal Gear Works, Inc., 1301 E. McNichols Rd., Detroit 3, Mich.

Circle **691** on inquiry card.

Sawing Machines. New 20-page Bulletin 54-702 describes and illustrates maker's "Contour-matic" versatile, semi-automatic machines for sawing, filing, grinding, and polishing.—DoAll Co., Des Plaines, Ill.

Circle **692** on inquiry card.

Lathe Accessories. New 40-page Catalog 5418 describes and illustrates maker's lathe, drill press, shaper and pedestal grinder accessories.—South Bend Lathe Works, 425 E. Madison St., South Bend 22, Indiana.

Circle **693** on inquiry card.

Milling Cutters. New 44-page Catalog 31 presents description, specifications and applications of maker's "Types A, H, J, L and C" face-milling cutters.—Lovejoy Tool Co., Springfield, Vt.

Circle **694** on inquiry card.

Die-casting Machines. New 2-page Data Sheet 5.4-4 describes application of maker's "Pyr-O-Vane" controllers for holding molten alloys at proper temperature prior to casting.—Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

Circle **695** on inquiry card.

Plastic Tooling. New 16-page bulletin "A Manual for Reinforced Plastics Tooling" illustrates and describes maker's plastic tools used as spotting racks, checking and inspection fixtures, welding and assembly fixtures, etc.—Marblette Corp., 37-21 30th St., Long Island City 1, N. Y.

Circle **696** on inquiry card.

Precision Gears. New 20-page booklet describes modern facilities for design and production of spurs and helical gears, pinions, sectors, ratchets, armature and splined shafts, etc.—Micron Gear Mfg. Co., 102-38 Corona Ave., Corona 68, N. Y.

Circle **697** on inquiry card.

Electromechanical Products. New 20-page brochure presents a digest-record of history, organization, research, development and production of company producing precision electromechanical devices.—Transitron, Inc., 154 Spring St., New York 12, N. Y.

Circle **698** on inquiry card.

Metal Stampings. New 16-page leaflet describes maker's clips, caps, rings and tube shields for standard and miniature-type tubes.—Fred Goat Co., Inc., 314 Dean St., Brooklyn 17, N. Y.

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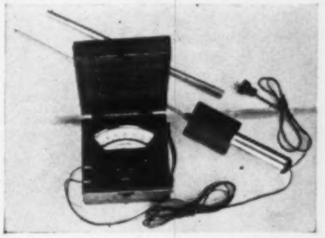

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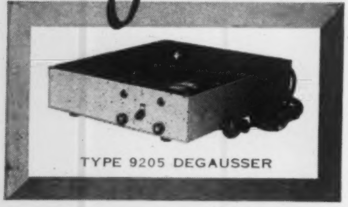

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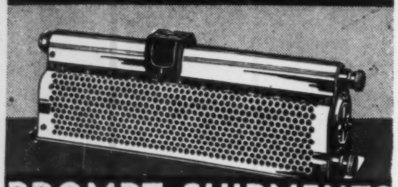

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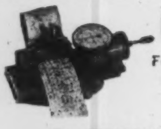

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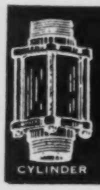

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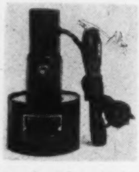

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NEW LITERATURE

Small Assemblies. New 16-page booklet "Fastening Techniques for Small Assemblies" shows how to save production dollars on fastening problems with small assemblies.—Milford Rivet & Machine Co., Milford, Conn.

Circle **700** on inquiry card.

Sander. New Bulletin 5080 pictures and describes maker's "Model D.A." dual-action sander for sanding, scuffing, feather edging, discing, polishing, buffing, etc.—Detroit Surfacing Machine Co., 1333 E. Eight Mile Rd., Detroit 20, Mich.

Circle **701** on inquiry card.

Screws, Pinions. New 4-page bulletin pictures maker's pinions for mechanical time fuses and watches, connector pins, miniature and subminiature parts for electronic equipment.—Histon Corp., 101 W. 31st St., New York 1, N. Y.

Circle **702** on inquiry card.

Cams, Jigs. New 4-page bulletin describes and illustrates maker's production facilities for producing swiss cams, jigs, fixtures, etc.—Precision Cam Co., Inc., 27 Bruckner Blvd., New York 54, N. Y.

Circle **703** on inquiry card.

Micro-Drill Guides. New 2-page circular describes maker's micro-drill guides. Includes chart on hole sizes, body sizes and lengths of guides.—Micro Drill Guide, 3980 Superior Ave., Cincinnati 36, Ohio.

Circle **704** on inquiry card.

Metal Products. New Bulletin 139 presents description of maker's custom fabrication of mild and stainless steels, aluminum and alloy metal parts.—Falstrom Co., 91 Falstrom Court, Passaic, N. J.

Circle **705** on inquiry card.

Plastic Tooling. New 20-page illustrated manual describes fabrication and indicates use of plastic tools as spotting racks, checking and inspection fixtures, welding and assembly fixtures, duplicate die models, etc.—Marblette Corp., 37-21 30th St., Long Island City 1, N. Y.

Circle **706** on inquiry card.

Shaped Wire. New 16-page illustrated Booklet DH-1226 describes ways of reducing machining costs with maker's shaped wire for grooved-choke wires, valve-stem key stock, snap rings, oil-retaining rings and lock spindles.—Page Steel & Wire Div., American Chain & Cable Co., Monessen, Pa.

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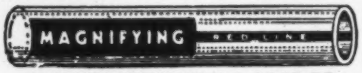

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MATERIALS

Packaging Material. New 4-page bulletin describes maker's "Hairflex" pillowed packaging material which is shock-resistant, dust-free and moisture-resistant.—Armour Curled Hair Div., North Benton Rd., Alliance, Ohio.

Circle **708** on inquiry card.

Laminated Plastics. New 12-page bulletin presents description on maker's "Insurok" laminated and molded plastics. Includes suggestive techniques for drilling, sawing, tapping, shearing, etc., and discusses typical applications using sheet, rods, and tubes.—Richardson Co., 2662 Lake St., Melrose Park, Ill.

Circle **709** on inquiry card.

Ceramics. New 4-page Bulletin 551 presents information on mechanical and electrical properties of maker's "A1SiMag" technical ceramics.—American Lava Corp., Chattanooga 5, Tenn.

Circle **710** on inquiry card.

Phosphor Bronze. New Technical Data Sheet 101 presents applications and physical characteristics of maker's phosphor-bronze.—American Silver Co., Inc., 36-07 Prince St., Flushing 54, N. Y.

Circle **711** on inquiry card.

Lubricating Film. New Bulletin 102 describes maker's "MOLY-Spray-KOTE" lubricating film used for prevention of seizing, galling and welding of metal parts.—Alpha Corp., 65 Harvard Ave., Stamford, Conn.

Circle **712** on inquiry card.

Ceramics. New 24-page 30th Anniversary Catalog pictures and describes maker's ceramics, including ball and socket or fish-spine beads and brown insulating beads, ceramic ferrules, hydraulic pressed parts, steatite tubing, etc.—Saxonburg Ceramics, Saxonburg, Pa.

Circle **713** on inquiry card.

Colloidal Graphite. New 4-page Bulletin 433 contains information, photographs, and charts on maker's colloidal graphite applications in electronic and electrical industries.—Acheson Colloids Co., Div. of Acheson Industries, Inc., Port Huron, Mich.

Circle **714** on inquiry card.

Teflon. New 4-page Bulletin 155 describes maker's "Teflon" material for shaft sealing, high-temperature sealing problems, low-frictional requirements, etc.—Sparta Mfg. Co., East Sparta, Ohio.

Circle **715** on inquiry card.

Silicone Grease. New 6-page Brochure 6-202 pictures and describes maker's 41 grease, silicone fluid-carbon black mixture for high-temperature, slow-speed bearings.—Dow Corning Corp., Midland, Mich.

Circle **716** on inquiry card.

Nickel Powder. Two new Data Sheets PMS-72 and 73 list chemical and physical properties of two grades of "Plast-Nickel" electrolytic nickel powder.—National Radiator Co., Johnstown, Pa.

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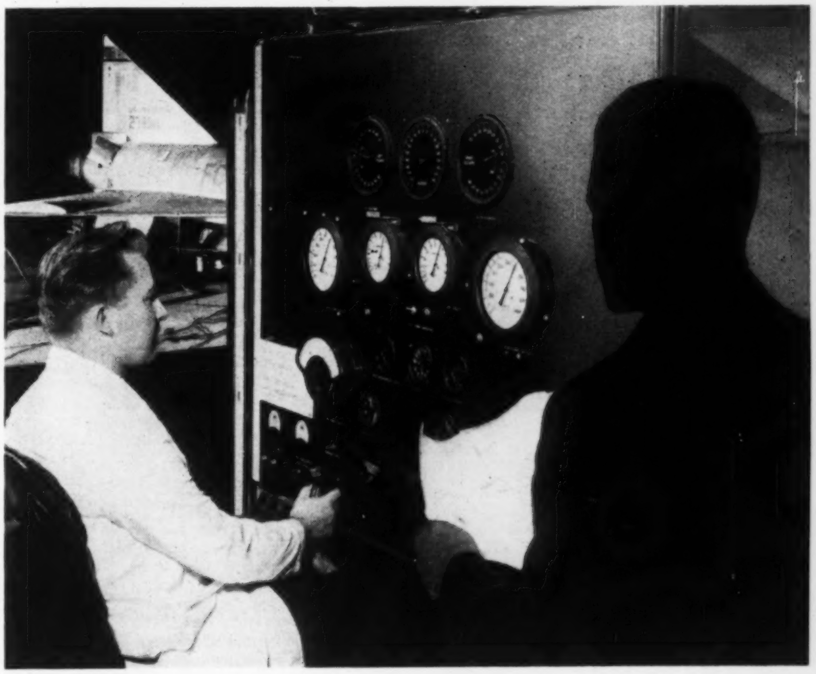

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211	231	251	271	291	311	331	351	371	391	
212	232	252	272	292	312	332	352	372	392	
213	233	253	273	293	313	333	353	373	393	
214	234	254	274	294	314	334	354	374	394	
215	235	255	275	295	315	335	355	375	395	
216	236	256	276	296	316	336	356	376	396	
217	237	257	277	297	317	337	357	377	397	
218	238	258	278	298	318	338	358	378	398	
219	239	259	279	299	319	339	359	379	399	
220	240	260	280	300	320	340	360	380	400	

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501	521	541	561	581	601	621	641	661	681	701
502	522	542	562	582	602	622	642	662	682	702
503	523	543	563	583	603	623	643	663	683	703
504	524	544	564	584	604	624	644	664	684	704
505	525	545	565	585	605	625	645	665	685	705
506	526	546	566	586	606	626	646	666	686	706
507	527	547	567	587	607	627	647	667	687	707
508	528	548	568	588	608	628	648	668	688	708
509	529	549	569	589	609	629	649	669	689	709
510	530	550	570	590	610	630	650	670	690	710
511	531	551	571	591	611	631	651	671	691	711
512	532	552	572	592	612	632	652	672	692	712
513	533	553	573	593	613	633	653	673	693	713
514	534	554	574	594	614	634	654	674	694	714
515	535	555	575	595	615	635	655	675	695	715
516	536	556	576	596	616	636	656	676	696	716
517	537	557	577	597	617	637	657	677	697	717
518	538	558	578	598	618	638	658	678	698	
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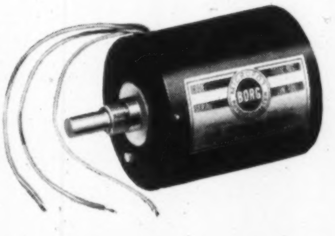

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